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**Imperial Institute of Agricultural Research,
Pusa**

*(Including the Reports of the Imperial Dairy Expert,
Physiological Chemist and Sugarcane Expert)*

1932-33



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Expert, Physiological Chemist and
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1932-33

REPORT OF THE DIRECTOR

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I. RESEARCH AND PROGRAMME OF WORK

SOIL FERTILITY

Of the principal plant-food materials in which the soils of India are deficient, by far the most important is nitrogen, and the manurial problem is, in the main, one of nitrogen deficiency. Depending, as India does almost exclusively, on the recuperative effects of natural processes in the soil to restore the combined nitrogen annually removed in the crops, studies of the nitrogen balance sheet, the factors influencing nitrogen fixation, and practical measures such as the use of leguminous crops and green manures are of great interest and importance.

The influence of leguminous crops in conserving the soil nitrogen when grown in mixture with a cereal is being tested by the Bacteriological Section for the last three years. As in previous years, the figures for total nitrogen remaining in the soil at the end of two years were less than at the beginning of the experiment in the *rabi* series, but in the *kharif* series they were higher. A gain is noticed in all plots in both series when the nitrogen removed in the crops is taken into account. The highest gain calculated in this way is 363 lb. per acre with a mixed crop of maize

and *urid* (*Phaseolus radiatus*) grown in the *kharif* season and 360 lb. per acre in the *rabi* series with maize and field peas grown in rotation. It appears that in certain years, if the season is favourable, maize plants may produce a greater amount of root secretion in the soil and there may be a greater accumulation of nitrogen at some seasons because of the stimulation of nitrogen-fixing organisms by such maize root secretions. It has incidentally also been observed that there is a seasonal fluctuation in nitrogen of the soil, that in April, May and June the *Clostridium* species of nitrogen-fixing organisms are predominant especially after the rains or when moisture is added to the soil, that organisms of the *azotobacter* type do not appear to multiply as rapidly as the *Clostridium* species, and that below the depth of one-fourth to three-fourths of an inch few *azotobacter* cells are present.

The field experiment started two years ago to find cheaper but equally efficient alternatives to sann-hemp as a green-manure will have to be run continuously for some years more before definite conclusions can be obtained, as the third year's results have revealed that the experimental area selected is not of uniform fertility. The experiment on the possibility of securing green-manure from land already growing another crop has been transferred to comparatively poor land. As in the previous year, but on poorer land, Mexican sunflower was planted along with onions. Expressed in yields per acre 51.6 maunds of onions and 230 maunds of sunflower (sufficient to manure one acre of land) were obtained, as against 89 mds. of onions from control plots growing that crop alone. It remains to be seen whether, as in the case of the richer land of the previous year, yields of subsequent crops would compensate for the loss in onions.

Apricot seed-cake, largely available in Simla Hills and at present mainly used as fuel, having been found to contain 6.7 per cent. nitrogen, 60 per cent. of which is in available form, pot experiments have been started with Pusa soil to which 20, 40, 80 and 100 lb. of nitrogen per acre are added in the form of cake, the crop grown being wheat. The application of 80 lb. of nitrogen gave practically the maximum crop production, and *Eleusine coracana* has been sown in the *kharif* to study the residual effect of the manure.

Among other investigations bearing on the maintenance or improvement of the fertility of soils may be mentioned those intended to elucidate the lime requirements of acid soils, the limiting factor of phosphate requirements in calcareous soils, the apparent ineffectiveness, or even depressing, effect of potassic fertilizers in Pusa soil, and the conditions under which the insoluble phosphate contained in apatite, called kudada phosphate, could be made available to the crops.

THE QUALITY OF AGRICULTURAL PRODUCE

The quality of agricultural produce depends upon its uniformity, its purity and its possession of some intrinsic property, e.g., high gluten content in wheat, oil-content in linseed, disease resistance in pigeon-pea. The spread of pure line seeds by the Agricultural Departments places a uniform product in the hands of the cultivator, and the maintenance of purity in the crop depends on the extent to which it is in the power of the ryot to carry out harvesting and sowing with some approach to modern methods. Improvement in any intrinsic property of a crop is the work of the plant-breeder and this section of the report is mainly concerned with what is being done at Pusa in this respect.

Wheat. Further proof of the outstanding quality of Pusa wheats has been received from Rhodesia where a prize for the best bag of seed wheat was won with Pusa 4. This variety is now extensively grown in New South Wales, and the Director of Plant Breeding in that State reports that it is among the 20 leading varieties grown there. Pusa 111, which did so well in milling and baking tests made in the United States of America as well as by the Research Association of British Flour Millers, is reported to be promising in comparison with Pusa 4. The wheat breeding work with the hybrids between Federation and Pusa 4 and Federation and Pusa 52 has now reached the stage at which yield trials are being conducted with the more promising hybrids. One of the hybrids (No. 1054) has been found in the U. S. A. resistant to five physiological forms of *Puccinia tritici*. Two late maturing hybrids having given very good results in the preliminary tests at Karnal are now known as P. 120 and P. 165. Large-scale tests with these hybrids in comparison with the standard Pusa and Punjab types will be made next year simultaneously at Pusa, at Karnal, and at several farms in the Punjab and the United Provinces under various climatic and other conditions including canal-irrigated, well-irrigated, and rain-fed lands. Some crosses with P. 111 as a parent promise to give at Karnal a bearded variety with the grain qualities of P. 111.

Barley. The purplish tinge on the seed surface of the heavy-yielding and plump-grained Type 21 isolated at Pusa renders it unsuitable for malting and brewing purposes. Hybridization has therefore been resorted to to evolve a strain combining the high yielding power of Type 21 parent and the white colour of the seed of the other parent, and some F_2 and F_3 generations studied during the year promise to provide the desired type.

Tobacco. As mentioned in previous reports, the problem of meeting the ever-increasing demand for a lighter and brighter tobacco is being tackled in the Botanical Section which has, by crossing a local type (Type 28) with an American Adcock, evolved hybrids which are now fixed and are breeding pure within narrow

limits. The progress of investigation in curing and yield was seriously hampered by the damage done by frost to the tobacco crop of the year under review. The system of flue-curing evolved at Pusa is, however, being widely adopted and the progressive tobacco-growing tracts are now dotted over with barns owned by ryots. The Chemical Section is continuing work on the relation of the changes taking place during various methods of curing in the quality of the cured leaf. After having established that the method of curing by picking the leaves from the stalk is more expensive and requires more space than the method of curing the leaves with stalks on and that leaves with stalks on are richer in nicotine content, the investigation was extended to determination of the albuminoid-amide and ash-potash ratios which along with nicotine have been recognized by several investigators as having a direct bearing on the quality of tobacco. A lower ratio in both cases is indicative of a better quality, but the year's results show that curing of leaves with stalks on though invariably tends to lower the albuminoid-amide ratio, in most cases it raises the ash-potash ratio.

Pigeon-pea. In a yield trial with the most promising types isolated, Types 15, 24, 51 and 64 proved significantly better than local seed. Type 51 is erect in habit and possesses a large yellow-brown seed and is also wilt-resistant. These characters together with its high yielding capacity should make this type of great economic importance. At the Etawah Agricultural Station (United Provinces), it gave an average outturn of 2,228.5 lb. per acre, and the Farm Superintendent reports that the crop was very little affected by frost in the month of January while local pigeon-pea in the adjoining fields of cultivators was badly damaged.

Indigo. One of the principal disadvantages under which natural indigo has to compete with synthetic indigo is that the former is sold in the form of dry cakes which have to be converted into a paste before being used for dyeing purposes, while the latter is sold as readily available paste. With a view to bring the natural product in line with the synthetic dye, experiments have been started in the Chemical Section on the standardization of natural indigo paste and its prevention from fermentation. Indigo paste prepared from cake powdered into a very fine state and mixed with water of equal weight, when treated with 1.5 per cent. sodium carbonate and heated in air oven at a temperature of 105 C. for 12 to 15 hours, has remained unchanged and free from fermentation for three months in sealed tins. It is proposed to extend the investigation to indigo paste available in indigo factories before its conversion into cakes.

In the case of other crops such as oats and sugarcane, the improved varieties evolved are distinguished by the superior quality of their produce, but as their value lies mainly in the

high acreage yields obtained, they are referred to in the succeeding section dealing with improvement of the yield of agricultural produce.

BREEDING IMPROVED AND HIGHER YIELDING VARIETIES

The work of breeding high yielding types of Indian crops constitute an important part of the duties of the Botanical Section and furnishes a source of practical training for the students. The success achieved by the Pusa varieties of crops and by the Coimbatore canes affords a measure of what has been and is being achieved.

Barley. Type 21 is maintaining its reputation as a high yielding barley; in North Bihar at Sepaya it gave an average yield of 1,868 lb. per acre in an area of 8.5 acres, beating the local barley significantly by 31 per cent., and at Gungowli the yield averaged 2,870 lb. This type has been adopted by the Deputy Director of Agriculture, Muzafferpur, for large-scale distribution of seed. Even under irrigated conditions in the United Provinces, when tried at four centres, it did better than the best form isolated by the local Department of Agriculture (Cawnpore Type 251) except at Raya in the Muttra District :—

Yield per acre

	Muzaffer-nagar	Cawnpore	Raya	Etawah
Pusa Type 21 . .	3,290.5	3,115.4	3,678.8	3,755.6
Cawnpore Type 251 .	2,714.0	2,489.0	3,826.0	..

Some Pusa barleys supplied to the Department of Agriculture, Victoria, Australia, are reported to be the most promising, among more than 100 importations from numerous countries, for use as parent-material. Types 12 and 20 have been mated there with Pryor and Plumage Archer for the early malting varieties, and with Cape for early feed. In addition, Type 24 is to be used for the production of an early feed type suited to the drier areas of the State.

Oats. The 12 hybrids fixed by crossing Pusa types with Abundance and Scotch Potato varieties were again tried simultaneously at Pusa (without irrigation) and Karnal (under irrigation) against the standard Pusa Types B. S. 1 and B. S. 2, and promising and interesting results were obtained. They will be repeated for the third time in the ensuing season, and it is hoped that the response of different types to variations in soil and climate will be elucidated by these trials. In a varietal trial at Sepaya in Bihar and Orissa,

the average yield of 2,854 lb. grain per acre given by B. S. 1 was superior to that of Hybrid C by about 30 per cent. On the other hand, at Raya in the United Provinces the outturn of green fodder per acre was 34,460 lb. in the case of Hybrid C as compared with 27,675 lb. yielded by B. S. 1.

Linseed. Of the hybrids obtained by crossing the high-yielding Pusa Types 12 and 121 of low oil-content with certain low-yielding Central Indian varieties of high oil-content, two, *viz.*, H. 55 and H. 21 have been found equal to the standard Type 12 in yielding power and to possess considerably higher oil percentage.

Variety	Oil percentage					
	1928-29	1929-30	1930-31	1931-32	1932-33	Mean.
Type 12	36.67	36.93	37.68	37.29	37.74	37.26
Hybrid 55 (T. 8 \times T. 121)	44.03	40.26	42.23	44.73	42.78	42.81
Hybrid 21 (T. 12 \times T. 8)	41.80	39.74	37.66	42.20	38.88	40.05

Both these hybrids have the 'white' seed colour which is more popular with the trade than the dark.

Gram. Extended trials at Pusa and Karnal have confirmed that in Type 58 we have definitely obtained a gram superior in yielding power to the established varieties. Similar trials are being organized in Sind, the Punjab and the United Provinces in collaboration with the local Departments of Agriculture. The other promising among the new types are Types 53, 54, 55 and 67.

Many other crops are also under investigation, for full details of which and of the numerous points of general interest connected with the work, reference should be made to the Report of the Botanical Section.

Sugarcane. For climatic reasons, breeding work on canes is done at Coimbatore by the Sugarcane Expert and his staff. It is now being supplemented at the Sub-station at Karnal financed by the Imperial Council of Agricultural Research where both crossed and selfed seeds obtained from the crosses made at Coimbatore are being successfully germinated. The improved types of thin and sub-tropical canes bred at Coimbatore have replaced the local types on 39 per cent. of the total acreage, and their high tonnage and greater sugar content have been one of the principal factors in the development of the indigenous white sugar industry which promises by 1934-35 to make India independent of foreign imports which were valued at Rs. 15.5 crores in 1929-30. No tariff however highly pitched would have brought into existence 27 new sugar factories in the United Provinces and Bihar and Orissa

during the year under report, had not improved varieties of cane been available to supply the requisite raw material without any very appreciable increase in the total acreage under the crop. Certain of these sub-tropical canes are now spreading in typically tropical parts of Madras where even a comparatively thin medium cane like Co. 281 has yielded in certain localities higher tonnages than a very thick type like Badila. The chief value of this class of canes in areas under thick types lies in lowering the cost of production—not a small consideration when the prices of agricultural produce have fallen so low. The breeding of new seedlings which will give heavy yields under a wider range of conditions than those for which the present popular Coimbatore varieties are suitable is being actively carried on. Among the new canes, Co. 313 and Co. 331 are the most promising, followed closely by Co. 299, Co. 326, Co. 301, Co. 244 and Co. 300. Co. 285 is justifying expectations entertained at the time of selection as likely to be an improvement on and replace Co. 205. In the farm at Patna this cane has shown considerable resistance to water-logging. Experience on the Karnal Sub-station indicates that Co. 312, Co. 357 (a sugarcane-sorghum hybrid) and Co. 313 are easily superior not only to the local Lalri but also to Co. 205 and Co. 285 which are displacing the local variety.

The work on thick or tropical canes was started more recently and the first batch of seedlings of the thick type was distributed only a couple of years ago, but satisfactory reports have already been received of the performances of Co. 402 and Co. 408 at various stations. In the preliminary test plots at Coimbatore, there are a number of later seedlings which promise to do better than the above-mentioned two canes.

Sugarcane-sorghum hybrids. The crossing of P. O. J. 2725 sugarcane with *Sorghum Durra*, with a view to obtaining a sugar-giving plant with a shorter growing period than sugarcane, has provided selected hybrids possessing certain common characteristics, *viz.*, fitness for milling after a growth of six to seven months, improvement in sucrose values when kept in the field for a longer period and comparatively high purities. One of these hybrids has recorded over 23 per cent. sucrose in juice and a second over 21 per cent. In the Madras Presidency, where on certain stations the hybrids are planted every month and analysed periodically to find out the best way of fitting these short-duration canes into the agricultural programme of the tract, Co. 352 planted at Anakapalle on the 1st September, 1931, and harvested on the 9th April, 1932, analysed as follows:—Brix 20·47 per cent., sucrose 17·90 per cent., glucose 0·31 per cent. and co-efficient of purity 87·46. As the F₁ generation obtained by crossing P. O. J. 2725 sugarcane with *Sorghum Durra* often includes a number of types which nestle close to the ground, show limited cane formation, possess thick leaves and are obviously of no value as sugarcane, the range of parents on

either side has been extended by including P. O. J. 213, Co. 213 and Co. 221 as mothers and *Sorghum guineense*, *S. cernuum*, *S. halepense*, *S. verticilliflorum* and *S. sudanense* as fathers. Though some of the original hybrids back-crossed with *Sorghum Durra* gave uneconomic types, the plants obtained by crossing them with *Saccharum sponta neum* were much like thin-stemmed sugarcanes.

At Pusa, an independent area of land measuring 150 acres is mainly devoted to sugarcane experiments. The testing of new Coimbatore canes for yield and other characteristics, tonnage trials with selected varieties, manurial experiments and general problems of cane cultivation form the basis of the work. The tests completed during the year indicate that Co. 299 is practically as early as Co. 214 and far superior to it in tonnage, that Co. 313 is another promising early variety, that Co. 331 represents the late cane required for crushing during April and May, and that Co. 285 is particularly suitable for water-logged areas. Work on Co. 281, as a cane suitable for irrigated areas under factory control, has now reached an estate scale and some 12 acres have been planted with it which, it is hoped, will definitely prove that an increased amount of sugar over the standard variety now irrigated can be obtained in a normal crop. Experiments with Co. 281 have shown that the damage caused to early ripening canes by jackals and pigs when left standing in the field for seed after the main crop is harvested, can be avoided by trashing of these canes for seed purposes.

PLANT DISEASES

In pursuance of the scheme for research on mosaic and other diseases of sugarcane financed by the Imperial Council of Agricultural Research, an intensive study of the mosaic virus has been taken up, and a new line of attack has been developed to find out the nature of the mosaic diseases, for details of which reference is invited to the Report of the Imperial Mycologist. Another year's results of the experiment to determine the effect of mosaic on the yield and juice of sugarcane indicate a loss, through mosaic, of four per cent. in juice. The occurrence of the red stripe disease caused by bacterial infection has been established for the first time in India. The causative organism has been isolated, and its biochemical reactions have been found to differ slightly from those of *Phytomonas rubrilineans* and *P. rubrisubalbicans* which are known to cause the red stripe in other sugarcane-growing countries. At Dacca and Sepaya, the disease has assumed serious proportions, the incidence being as much as 80 per cent. in some varieties. It does not kill the cane outright but the growth is checked, and in cases where the top shoot is affected there is appreciable loss. The species of *Fusarium* causing top-rot has been identified as *Fusarium moniliforme* and its parasitism established. The yellowing of

canes has been ascertained to be a deficiency disease, clumps manured with either potasium sulphate or ammonium sulphate reviving and assuming a healthy appearance.

Observations made in two consecutive years on the stem-rot disease of *Hibiscus subdariffa* caused by *Sclerotinia sclerotiorum* have shown that the disease appears in January, that the parasite develops the ascospore stage only in the cold weather and that infection is mainly due to these spores. It would therefore appear that varieties maturing by the time the disease appears would automatically escape infection, and attempts are being made to see if the type under study could be made to set seed a little earlier.

That kerol when applied to the soil in a concentration of 0.07 per cent. is effective in controlling foot-rot of *Piper betel* caused by *Rhizoctonia solani* and *Sclerotium rolfsii* was confirmed, and phenyl too in 1 and 0.5 per cent. strengths has proved an equally efficient soil disinfectant.

The experiment to test the comparative resisting power of 24 types of Pusa barleys to *Helminthosporium* together with the effect of uspulun as a seed treatment was repeated, and the efficiency of uspulun to control the disease was confirmed. It was incidentally proved that this fungicide also checks the attack by smut (*Ustilago hordei*).

With a view to controlling the seedling diseases caused by *Rhizoctonia*s seed treatment was tried on chillies and tobacco. Mercury bichloride, uspulun, granosan and germisan were tested, and in each case excellent results were recorded, the dust treatment (granosan) giving better result.

Treatment of gram seed in a solution of either formalin or uspulun, or with sulphur or ceresan, and spraying of the crop with one per cent. Bordeaux mixture or dusting with colloidal sulphur RV3 are all being tried to control the leaf blight of gram caused by *Mystrosporium* sp. The experiment will have to be repeated for some years to obtain sufficient data to draw conclusions from.

Among other diseases under investigation may be mentioned, those of wheat caused by *Tilletia*, *Helminthosporium* and *Puccinia*, the *Sclerotium* disease of rice, the wilt disease of *Crotalaria juncea* and the stem-rot of tobacco. A survey of diseases of fruit trees in British Baluchistan was undertaken during the year and several fungi were recorded there for the first time.

INSECT ATTACKS

As in previous years, sugarcane borers and other insect pests of sugarcane received considerable attention in the Entomological Section. Despite systematic destruction of egg-masses of the top-

shoot borer and removal of "dead-hearts" and damaged shoots and occasional treatment with 0·5 per cent. crude oil emulsion, the mean percentage of insect infection in mosaic tonnage experimental plots was slightly more than that of last year and as follows :—

Insects	Mosaic free plots	Mosaic plots
Top-shoot borers (<i>Scirpophaga nivella</i> Fabr.)—		
Early attack	10·9	10·5
Late attack	26·02	26·7
Stem-borers (<i>Argyria sticticraspis</i> Hmpn., <i>Diatraea venosata</i> Wlk., <i>Chilo zonellus</i> Swinh.) . .	4·35	4·36
Root-borer (<i>Emmalocera depressella</i> Swinh.) . . .	9·29	9·2
Termites	9·5	8·58

From samples taken at random, from cane fields in the New Area, the average loss in weight in mosaic-free Co. 213, caused by the top-shoot borer, was found to be 15·4 per cent. Among other cane pests under observation are *Pyrilla* spp., *Aleurolobus barotensis*, *Neomaskellia bergi*, *Gryllotalpa africana*, *Mylocerus discolor* and Elaterid grubs.

A preliminary survey of the various insect pests reported to be causing enormous damage to the fruit trees in Baluchistan was carried out with a view to devising control measures to be carried out by the local agency.

Poison baits consisting of sweetened bran mixed with barium carbonate were more successful than those containing potassium cyanide against rats causing damage in paddy fields and stored rice.

The linseed crop of the Botanical Section was attacked by a Cecidomyiad fly the pinkish larvæ of which were found feeding upon the pollen of the flowers in March 1933. A light trap was set up for about two weeks and a fairly good number of flies were killed. The incidence of *Agrotis ypsilon* was checked by poison baits.

The life-histories of about 80 insects were studied partly or fully, and some observations were made on the habits and habitats of the Asilidæ of Pusa.

THE SPREAD OF IMPROVED VARIETIES OF CROPS.

The work of the plant-breeder in evolving improved varieties of crops is obviously merely a means to an end, and the most direct proof of its value is given by the records of the amount of improved seeds, etc., distributed to growers. In the past season the Botanical Section and its Sub-station at Karnal, and the Agricultural Section at Pusa distributed to Provincial Departments of Agriculture and to private growers the following quantities of seed of improved varieties :—45,025 lb. of wheat, 7,860 lb. of barley, 7,826 lb. of oats, 10,310 lb. of gram, 2,430 lb. of pigeon-pea, 3,540 lb. of linseed, 24.5 lb. of tobacco, 255,533 lb. of sugarcane setts and 1,618 lb. of maize and miscellaneous. The Sugarcane Station at Coimbatore supplied preserved sugarcane seeds to the Economic Botanist at Shahjahanpur in the United Provinces and to the Sugarcane Specialist at Mushari in Bihar and Orissa. The Sugarcane Research Station at Shahjahanpur was also supplied with 5,000 seedlings of parentage likely to be useful in the United Provinces. In addition, 412 packets of seed canes were sent to various parts of India. These figures, large as they are, correspond to only a small fraction of the actual area covered by improved varieties bred at Pusa and Coimbatore, for the spread of improved seeds is mainly carried out by Local Departments of Agriculture who obtain yearly relatively small quantities of seed from Pusa and multiply this for distribution to ryots. For instance, of 1,059,840 maunds of seed distributed in the United Provinces in 1930-31, 80 per cent. was of sugarcane and 16 per cent of wheat, and the improved varieties of these crops adopted for departmental seed distribution are mainly those originally emanating from Coimbatore and Pusa respectively. The maintenance of the standard of improvement which the original introduction offered is of vital importance, and a regular system for maintaining the purity of the seed supply of the established Pusa wheats has been formulated in the Botanical Section. Seed is taken from typical single plants of each type every year and in the succeeding year is sown in five rows. Seed from the five rows is sown in a small plot in the next year and from this plot sufficient seed is obtained to sow one acre in the following year. From this, seed is given in the next season for sowing on ten-acre plots on the Pusa Farm. The crop on the Farm is therefore only four generations removed from a single plant and this seed is available for distribution to different Departments of Agriculture and others.

AGRICULTURAL MACHINERY

The Marshall Diesel tractor purchased in March 1932 had a full year's trial, and the results of the year's working have shown that the crude oil tractor is as easy to start, manipulate and work.

as any kerosene oil tractor, and whether the agricultural operation carried out is ploughing, disc-harrowing or grubbing, the cost per acre is comparatively lower by more than 33 per cent. Investigations into the design of a small thresher suitable for Indian conditions and marketable at a price within the range of small landowners have resulted in a type which has successfully stood an exhaustive test. During 57·590 working hours over a period of 16 days, 239·860 maunds of grain were obtained, the average output per hour being 4·16 maunds.

CATTLE BREEDING AND DAIRYING

Pusa. The new system of feeding and handling referred to in last year's report was worked throughout the year and the average yield of milk per day per cow in the pure bred Sahiwal herd was raised from 13·6 lb. to 17·9 lb. and the percentage of cows in milk increased from 50·2 to 55·1. In June 1933, the average yield per cow per day stood at the record figure of 19·2 lb. The previous herd record of 7,053 lb. in a lactation period of 10 months, which had remained unbeaten for seven years, was surpassed by six cows who gave 8,863, 8,081, 8,060, 7,901, 7,254 and 7,226 lb. respectively, and two heifers outdistanced the previous heifer record of 5,785 lb. achieved in 1921 by 1,863 and 1,234 lb. respectively. One cow which has been allowed to pass over the fixed lactation period of 304 days has done 9,746 lb. in 447 days and is giving 12 lb. daily at the time of writing. Without increasing the general expenses of the herd, the new system has resulted in an increase in the total milk yield by 47 per cent., a reduction in the service period, a steady rise in weight after reaching milking condition, and a steady maintenance of the average fat percentage of 4·7 in the milk yield throughout. Marked gains in body weight and more rapid maturity were obtained under a special system evolved for rearing pail-fed calves, and the mortality percentage was reduced from 4·3 to 1·4.

Karnal. Breeding work with two indigenous breeds, *viz.*, *Hariana* and *Thar Parkar*, on dual purpose lines is being continued. There has been steady improvement in milk yield, and records of over 8,000 lb. per lactation have been obtained in both herds. Systematic recording of fat percentage in the milk of individual cows has showed that the Indian cattle can yield as high percentage of fat as 7·8, and instances of animals with a 6·5 per cent. fat are quite common.

Bangalore. In addition to the original herd of *Scindi* cattle, a foundation herd of *Gir* cattle obtained from their original home in *Kathiawar* has been started in pursuance of the policy laid down by Government to concentrate attention on providing high yielding strains of indigenous breeds of cattle.

ANIMAL NUTRITION

An year's work by the Physiological Chemist on the influence of high and low protein feeding on milk production has not provided data from which definite conclusions can be drawn, but it appears that the composition of the milk is not perceptibly affected by the difference in feeding practice. There is also an indication, which requires confirmation, that the higher protein ration prolongs the lactation period slightly, which is suspected to have deleterious effects on the cows.

Various Indian coarse fodders are being tested for digestibility: feeding experiments with *juar* stalks in the prime stage as they came in from the field and with identical material converted into hay have shown that conversion into hay leads to a notable increase in the crude fibre fraction and corresponding serious lowering of digestibility of the carbohydrates. Experiments have also been undertaken to elucidate whether marked physical differences exist between the carbohydrates of such distinct products as rice straw, *ragi* (*E. coracana*) straw, sorghum and hay which possess distinct digestibility co-efficients. In view of the desirability of encouraging the production and utilization of legume hays an investigation into the best method of preparing them, their digestibility and their effect on the nitrogen balance has been undertaken.

The effect of supplementing a fodder ration with a mineral is being tested both with growing animals and adult bullocks. In the case of the former it has been noticed that 0.73 per cent. lime and 0.47 per cent. phosphoric acid in the basal ration suffice for normal growth. In the latter case the fodders used are rice straw and sorghum hay, and the mineral is calcium phosphate which at one stage was also supplemented by green food. Determinations of mineral balance have indicated that rice straw provides just enough phosphoric acid but not enough lime, while in sorghum hay there is a sufficiency of both lime and phosphoric acid. The results of both experiments have emphasized that a mineral supplement has no effect in cases where enough is present in the fodders themselves.

The object of another investigation is to determine comparative values of the mineral composition of grasses grown on selected typical soils in various parts of India. It has been observed that the protein content is a specific character and that the mineral contents vary with the stage of maturity, the dead ripe stage producing very poor quality.

In addition, various physiological studies are in hand, for which reference should be made to the Report of the Physiological Chemist.

Experiments undertaken on the Pusa Farm to arrive at the best method of preserving berseem in silo pits have shown that there

is least wastage when berseem and oats straw are placed in alternate layers in the proportion of 3 : 1 by volume, that green oats if available can also be used in place of oats straw, and that March and April cuts of berseem being less watery are most suitable for siloing and give better value. It is now possible to keep the Pusa milch herd for the whole year, if necessary, on a ration of either green berseem, berseem hay or berseem silage, and no other green fodder crop need be grown. The effect of treating berseem to be siloed with 0.1 per cent. hydrochloric acid or of adding about 10 per cent. molasses is being investigated in the Bacteriological Section.

II. GENERAL ADMINISTRATION

Charge. Dr. F. J. F. Shaw officiated as Director up to the 29th December 1932, when Dr. W. McRae resumed charge on relinquishing the officiating appointment of Agricultural Expert to the Imperial Council of Agricultural Research.

On reversion from the post of Director, Dr. Shaw took over the duties of Joint Director of the Institute from Mr. Wynne Sayer who was officiating in the post.

Staff. Owing to absences on leave, etc., the following changes in the charge of Sections were made :—

Mycological Section. Dr. M. Mitra up to the 29th December 1932, *vice* Dr. McRae on other duty.

Animal Nutrition Section. Mr. A. V. Iyer up to the 8th November 1932, *vice* Dr. F. J. Warth on leave.

Mr. T. Bainbrigge Fletcher who proceeded on leave with effect from the 6th April 1932, retired from the post of Imperial Entomologist on attaining superannuation age on the 25th March 1933. Mr. P. V. Isaac officiated as Imperial Entomologist throughout the year, and so did Mr. Wynne Sayer as Imperial Agriculturist. Messrs. J. N. Mukerji and N. V. Joshi, both Class II officers, continued to be in charge of the Chemical and Bacteriological Sections respectively.

Except in the case of certain specialized posts such as Cattle Superintendent, Statistician, etc., the designations of Assistant Mycologist, 2nd Assistant Mycologist, Assistant Agricultural Chemist, etc., have been adopted during the year for the gazetted officers of this Institute who are not in Class I Service.

Extensions. A beginning has been made in the organization of the new sub-section of statistics by the appointment of one computer, and the candidate selected by the Public Service Commission for the post of Statistician has since the close of the year entered upon his duties. The Commission has also made a selection for the post of Second Economic Botanist, and the

Botanical Section has been restored to its original strength of two Class I officers. The Imperial Council of Agricultural Research has sanctioned a grant of a sum of Rs. 31,200 for a five-year scheme for conducting research work on the genetics of sugarcane at the Imperial Cane-breeding Station, Coimbatore, and it is hoped that a start will be made with the scheme before the end of the current year when the Geneticist selected by the Public Service Commission will have taken up her duties.

Training. Provincial Committees for selection of students for post-graduate courses of the highest possible standard given at the Pusa Institute, foreshadowed in last year's report, have been constituted in some provinces, and of the 34 candidates applying for admission to the session beginning in November 1932, fifteen were the nominees of such committees. Sixteen applicants were selected for admission: seven in Botany, of whom two left subsequently on obtaining appointments, one in Entomology, two in Chemistry, three in Sugarcane Breeding, and three in General Agriculture. During the year under report four post-graduate students completed the two-year course at Pusa, three in Botany and one in Chemistry. The one-year course in farm organization, farm management and general farm engineering was completed by one student.

The fifteen-month post-graduate course in animal husbandry, animal nutrition and dairying was completed by one student in April 1933. Of the four applicants for admission to the new session beginning in January 1932, two were selected but one actually joined.

The class of 19 Indian Dairy Diploma students started in November 1931 was strengthened by the admission of one repeat course student. As the year under report was the intervening year no fresh admissions were made.

A number of students and post-graduate workers were also admitted for periods of work or training in various Sections of the Institute. A batch of 28 British soldiers took at the Bangalore Dairy Farm a six-month vocational course in practical dairying, and another batch of 15 soldiers was admitted on 1st June 1933 for a similar course. A special course of training in the flue-curing of tobacco lasting for six weeks was organized at Pusa, and, although there were a number of applicants, for want of accommodation only seven students could be admitted to it.

Library. Publications received in exchange numbered 1,941, while 461 were purchased. Of the 3,744 books, etc., issued on loan, 516 were to scientific workers in the provinces and universities. With a view to providing adequate storage space for the ever-increasing number of books in the library one additional room was fitted up with shelves during the year under report.

Buildings. The building programme at the Botanical Sub-station estimated to cost a total sum of Rs. 64,200, for which the Government had accepted liability, was completed, but no funds were available for any other major original work elsewhere.

Hospital. There were 341 in-patients and 5,117 out-patients in 1932, and 326 operations were performed. The health of the residents of the Estate was, on the whole, satisfactory.

III. ACCOUNTS

The total expenditure for the Institute and its out-stations during the financial year ending the 31st March 1933 amounted to Rs. 9,09,599, as against Rs. 11,89,001 for the previous year.

Name of establishment	Expenditure Rs.
General expenditure of the Institute, including the office of the Director, Power and Gas Plants, the Medical and Estate Establishments	1,98,013
Agricultural Section	1,31,978
Botanical Section	44,856
Chemical Section	34,968
Mycological Section	25,899
Entomological Section	53,919
Bacteriological Section	37,724
Imperial Dairy Expert	29,739
Bangalore Dairy	1,29,568
Wellington Dairy	39,560
Karnal Cattle Breeding Farm	70,987
Physiological Chemist, Bangalore	33,738
Sugarcane Station, Coimbatore	78,650
	<hr/> 9,09,599* <hr/>

The cost of the Botanical and Sugarcane Sub-stations at Karnal and the scheme for research on mosaic and other diseases of sugar-canes amounting to Rs. 21,606, Rs. 20,312 and Rs. 12,140, respectively, was met from the funds of the Imperial Council of Agricultural Research.

The receipts of the Institute and its out-stations amounted to Rs. 2,84,316* as shown below :—

	Sale of dairy pro- duce and live-stock	Sale of farm produce	Fees from students	Miscel- laneous receipts	Total
Pusa Institute . .	21,884	19,101	3,525	11,315	55,825
Bangalore Dairy . .	1,09,217	609	2,205	4,529	1,16,560
Wellington Dairy . .	50,429	865	278	2,738	54,310
Karnal Farm . .	21,484	23,566	..	3,871	48,921
Coimbatore Sugarcane Station . . . .	..	..	..	..	8,800
TOTAL . .	..	..	..	..	2,84,416

*Provisional figure.

REPORT OF THE IMPERIAL AGRICULTURIST

[WYNNE SAYER, B.A., DIP. AGRI. (CANTAB.)]

I. CHARGE

Mr. Wynne Sayer was in charge of the Agricultural Section throughout the year. Mr. L. S. Joseph, Cattle Superintendent, was deputed for training in the post-graduate refresher course at the Imperial Institute of Veterinary Research, Muktesar, and Mr. S. M. Jamaluddin, Second Cattle Superintendent, was appointed to act as Cattle Superintendent during Mr. Joseph's deputation.

II. POST-GRADUATE TRAINING

One post-graduate student completed his training in general agriculture on the 31st October 1932. Three new post-graduate students for training in general agriculture (one from Bihar and Orissa, one from the United Provinces and one from the Punjab) and one post-graduate student from the Punjab for a two-year course in sugarcane research were admitted from the 1st November 1932. One post-graduate student from the Animal Husbandry and Dairying Section, who joined on the 16th December 1932, finished his training on the 30th March 1933.

III. SEED SUPPLY

The following seeds of the improved varieties of crops were distributed during the year :—

	lb.		lb.
Wheat Pusa 4 . . .	2,205·2	Barley T. 21 . . .	4,525·7
" " 12 . . .	1,603·0	Lentils T. III-86 . . .	534·9
" " 111 . . .	503·4	Linseed T. 121 . . .	345·6
" " 52 . . .	7,858·7	" T. 124 . . .	329·1
" " 80—5 . . .	205·7	" T. 12 . . .	637·7
	<hr/> 12,376·0		<hr/>
Oats B. S. I . . .	4,155·4		
" " " II . . .	1,008·0		
	<hr/> 5,163·4		<hr/> 1,312·4
Pigeon-pea T. 69 . . .	82·3	Maize No. 1 . . .	46·3
" T. 16 . . .	20·3	" No. 2 . . .	15·4
	<hr/> 102·6	" No. 3 . . .	169·7
			<hr/> 231·4

	Ib.			Ib.
Soybean-Chocolate	102.9	Sugarcane	Cc. 299	3,497.1
Gram T. 58	715.9	"	Co. 300	3,970.3
" T. 17	1,414.3	"	Co. 301	4,608.0
" T. 25	442.8	"	Co. 312	493.7
" No. 15	115.2	"	Co. 313	3,929.1
		"	Co. 318	2,427.4
	2,688.2	"	Co. 326	864.0
		"	Co. 331	4,443.4
		"	Co. 335	288.0
Pea No. 1	54.8	"	Co. 336	164.6
" No. 2	41.1	"	Co. 341	576.0
" No. 4	2.1	"	Co. 342	3,126.9
	98.0	"	Co. 345	82.3
		"	Co. 346	905.1
		"	Co. 351	41.1
Sann-hemp	1.0	"	Co. 352	123.4
		"	Co. 353	82.3
		"	Co. 355	164.6
Cowpeas	82.3	"	Co. 356	164.6
		"	Tuc. 393	41.1
Sugarcane Co. 210	267.4	"	Tuc. 472	41.1
" Co. 213	2,108.6	"	P. O. J. 2878	4.1
" Co. 214	13,350.9			
" Co. 281	2,715.4			255,532.7
" Co. 285	207,052.2			

IV. CROP STATEMENT

The following statement gives the principal crops grown on the farm and yields obtained :—

Crop	Area in acres	Yield in maunds	
		Total	Average per acre
Sugarcane	47.04	24,849.80	528.05
Maize corn	115.20	1,690.35	14.67
Maize, green fodder	145.54	29,794.00	204.71
Wheat P. 4*	10.00	130.50	13.05
Wheat P. 12*	9.00	146.32	16.25
Wheat P. 52*	10.00	159.90	15.99
Other wheat varieties*	21.78	232.45	10.67
Barley T. 21	21.50	501.33	23.31
Arhar (<i>Cajanus indicus</i>)*	61.79	396.65	6.42
Peas*	22.28	118.23	5.31
Oats	186.94	3,476.60	18.59
Berseem†	58.77	15,133.75	257.51

*Crops damaged by frost.

† The figures for berseem include four cuts and no grazing.

V. EXPERIMENTAL WORK

The following experiments were conducted by the Agricultural Section during the year under report :—

1. *Manurial experiments—*

(a) Permanent manurial and rotation experiments.

(b) Randomised blocks laid down for check test experiments on the above treatments.

(c) Manurial experiments with double superphosphate on oats—one maund *versus* two maunds per acre.

(d) Green-manure experiments with sann-hemp, *guar* (*Cyamopsis psoralioides*), *meth* (*Phaseolus aconitifolius*) and cowpeas on oats.

(e) Green-manure and superphosphate experiments on oats.

(f) Manurial experiments with sulphate of potash and muriate of potash on berseem.

(g) Manurial experiments with superphosphate on sugarcane : 50 lb., 75 lb., 100 lb. P_2O_5 per acre.

(h) Manurial experiments with nitrogen on sugarcane : 40 lb., 50 lb. and 80 lb. nitrogen per acre in the form of oil-cake.

(i) Manurial experiments with superphosphate and oil-cake on sugarcane : 50 lb. P_2O_5 *plus* 40 lb., 60 lb. and 80 lb. nitrogen per acre.

(j) Manurial experiments with superphosphate and nitrogen (oil-cake) on sugarcane : 75 lb. P_2O_5 *plus* 40 lb., 60 lb. and 80 lb. nitrogen per acre.

(k) Manurial experiments with superphosphate and nitrogen (oil-cake) on sugarcane : 100 lb. P_2O_5 *plus* 40 lb., 60 lb. and 80 lb. nitrogen per acre.

(l) Manurial experiments with diammonphos and standard dressing (40 lb. nitrogen *plus* 50 lb. P_2O_5) on sugarcane.

(n) Manurial experiments with superphosphate and oil-cake on sugarcane : 100 lb. P_2O_5 and 80 lb. nitrogen per acre.

(n) Manurial experiments with oil-cake application—one dose *versus* two doses on sugarcane.

(o) Manurial experiments with sulphate of ammonia and nitrate of soda on sugarcane.

2. *Varietal yield trials with—*

- (a) *Arhar*.
- (b) Soybean.
- (c) Maize for corn.
- (d) Maize for fodder.
- (e) Gram.
- (f) Peas.
- (g) Barley.
- (h) Oats.
- (i) Wheat.
- (j) Sugarcane Co. 210 *versus* Co. 331.
- (k) Sugarcane Co. 210 *versus* Co. 213.
- (l) Sugarcane Co. 214 *versus* Co. 299.
- (m) Sugarcane Co. 300, Co. 301, Co. 302, Co. 312 and Co. 316.
- (n) Sugarcane Co. 210, Co. 213, Co. 214 and Co. 281.

3. *Experiments for other sections of the Institute—*

(a) Manurial experiments with various chemical manures on sugarcane for the Imperial Agricultural Chemist.

(b) Green-manure experiments for the Imperial Agricultural Bacteriologist—maize and wheat, sann-hemp and wheat, *urid* (*Phaseolus mungo*) and wheat, sann-hemp tops and wheat.

(c) Green-manure experiments with sann-hemp, sann-hemp tops, *urid* and soybean on wheat.

(d) Varietal trials with wheat for the Imperial Agricultural Bacteriologist—P. 52 *versus* country.

(e) Mosaic tonnage experiments with Co. 213: healthy *versus* mosaic, for the Imperial Mycologist.

4. *Miscellaneous experiments—*

(a) Trashing for seed-cane with sugarcane variety Co. 281.

(b) Berseem silage investigations.

(c) Experiments to ascertain the effect of speed of tractor-drawn implements on soil tilth and crop yields.

(d) Spacing experiments with maize for corn.

(e) Sugarcane-cutting experiments with Co. 213 at Meghaul for ascertaining correct size of experimental plots.

VI. RESULTS OF FIELD AND OTHER EXPERIMENTS

1. MANURIAL EXPERIMENTS

(i) *Permanent manurial and rotation experiments.* The experiment was continued on the same lines as before in the Punjab field, Blocks 'B' and 'D'. The following are the chemical analyses of manures applied to the experiment :—

Name of manure	N %	P ₂ O ₅ %	K ₂ O %
Farmyard manure	0.72	0.50	0.48
Rape cake	5.65	..	..
Sulphate of ammonia	20.74	..	..
Sulphate of potash . . . . .	..	..	48.42
Superphosphate . . . . .	..	39.57	..

Wheat and *arhar* crops were damaged by frost and the effect was marked on certain plots in these experiments.

Results of permanent manurial and rotation experiments for the year 1932-33

Treatment	A SERIES			B SERIES	
	KHARIF 1932	RABI 1932-33		KHARIF 1932	RABI 1932-33
	Maize grain per acre in	<i>Arhar</i> grain per acre in	Barley grain per acre in	Maize grain per acre in	Wheat grain per acre in
GROUP I	lb.	lb.	lb.	lb.	lb.
1 No manure (Check plot No. 1).	337	1,339	..	716	339
2 Farmyard manure @ 4,000 lb. per acre.	838	1,224	..	1,215	555
3 Farmyard manure @ 8,000 lb. per acre.	1,306	1,191	..	1,618	686
4 Farmyard manure @ 4,000 lb. per acre <i>plus</i> rape cake to supply 20 lb. nitrogen per acre at the time of last interculture.	1,445	1,150	..	1,601	639
5 Rape cake @ 40 lb. nitrogen per acre, half to be applied just before <i>kharif</i> sowing and half to be applied at last interculture.	1,117	1,199	..	1,334	370

Treatment	A SERIES			B SERIES	
	KHARIF 1932	RABI 1932-33		KHARIF 1932	RABI 1932-33
	Maize grain per acre in	Arhar grain per acre in	Barley grain per acre in	Maize grain per acre in	Wheat grain per acre in
GROUP II	lb.	lb.	lb.	lb.	lb.
6 Sulphate of ammonia @ 40 lb. nitrogen per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> is sown it is to be applied in one dose in <i>kharif</i> .	222	1,088	..	509	263
7 Sulphate of potash @ 50 lb. K_2O per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> crop is sown it is to be applied in one dose in <i>kharif</i> .	665	936	..	579	241
8 Superphosphate @ 80 lb. P_2O_5 per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> is sown it is to be applied in one dose in <i>kharif</i> .	304	1,211	..	1,084	605
9 Sulphate of potash @ 50 lb. K_2O per acre and superphosphate @ 80 lb. P_2O_5 per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> is sown they are to be applied in one dose in <i>kharif</i> .	411	1,141	..	985	661
10 Sulphate of ammonia @ 40 lb. nitrogen, sulphate of potash @ 50 lb. K_2O and superphosphate @ 80 lb. P_2O_5 per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> is sown they are to be applied in one dose in <i>kharif</i> .	584	1,211	..	1,314	839

Treatment	A SERIES			B SERIES	
	KHARIF 1932	RABI 1932-33		KHARIF 1932	RABI 1932-33
	Maize grain per acre in	Arhar grain per acre in	Barley grain per acre in	Maize grain per acre in	Wheat grain per acre in
	lb.	lb.	lb.	lb.	lb.
GROUP II—contd.					
11 Sulphate of ammonia @ 40 lb. nitrogen and superphosphate @ 80 lb. P_2O_5 per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> is sown they are to be applied in one dose in <i>kharif</i> .	140	1,577	..	1,002	704
13 No manure (Check plot No. 2).	107	640	..	302	261
14 Sulphate of ammonia @ 40 lb. nitrogen per acre, sulphate of potash @ 50 lb. K_2O per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> is sown they are to be applied in one dose in <i>kharif</i> .	246	402	..	370	326
GROUP III					
12 Green manure in conjunction with a purely cereal rotation.	Green manure	..	859	Green manure	199
15 Effect of green manure and leguminous crop in the rotation.	805	230	..	Do.	702
16 As for plot No. 15 but with an additional application of superphosphate @ 80 lb. P_2O_5 per acre to be applied with green manure only.	994	665	..	Do.	1,987
17 No leguminous crop and no green manure.	747	..	402	649	252
18 No manure (Check plot No. 3).	575	411	..	706	425

(ii) *New manurial experiments.* The experiment was started with a view to obtain a statistically significant result from the manuring programme followed on the permanent manurial plots. It has been laid down in the Punjab field, Block A, in "Randomised Blocks" with 10 treatments and 10 replications. The area of each plot is 1/40 acre.

The following four-year eight-course cropping scheme will be followed :—

1. Maize and oats, 1932-33.
2. Maize and peas, 1933-34.
3. Maize and wheat, 1934-25.
4. Maize and gram, 1935-36.

The following are the ten treatments adopted in the experiment :—

A. No manure.

B. Farmyard manure at 8,000 lb. per acre. Total amount to be applied in the last week of April or first week of May.

C. Rape cake at 40 lb. nitrogen per acre, half to be applied just before *kharif* sowing and half to be applied at the time of last interculture.

D. Sulphate of ammonia at 40 lb. nitrogen per acre, half before *kharif* sowing and half before *rabi* sowing.

E. Sulphate of potash at 50 lb. K_2O per acre, half before *kharif* sowing and half before *rabi* sowing.

F. Superphosphate at 80 lb. P_2O_5 per acre, half before *kharif* sowing and half before *rabi* sowing.

G. Sulphate of potash at 50 lb. K_2O per acre, and superphosphate at 80 lb. P_2O_5 per acre, half before *kharif* sowing and half before *rabi* sowing.

H. Sulphate of ammonia at 40 lb. nitrogen per acre, superphosphate at 80 lb. P_2O_5 per acre and sulphate of potash at 50 lb. K_2O per acre, half before *kharif* sowing and half before *rabi* sowing.

I. Sulphate of ammonia at 40 lb. nitrogen per acre and superphosphate at 80 lb. P_2O_5 per acre, half before *kharif* sowing and half before *rabi* sowing.

J. Sulphate of ammonia at 40 lb. nitrogen per acre and sulphate of potash at 50 lb. K_2O per acre, half before *kharif* sowing and half before *rabi* sowing.

The results are :—

Mean yield per plot in lb.

Treatment	Maize P. F. 2	Oats B. S. II
A	17·790	11·352
B	21·458	21·721
C	25·505	22·435
D	20·116	15·209
E	18·208	15·197
F	18·802	14·415
G	16·770 ✓	10·279 ✓
H	21·911	22·534
I	21·902	23·485
J	21·166	15·082

In both cases Fisher's 'z' test was applied and the results were significant at the one per cent. level. Fisher's 't' test was also applied for testing the mean differences between the treatments and the result was almost identical with both crops.

It was found with both crops that the treatments were divided into two distinct groups with significant difference between them but the differences between the treatments in each group were not significant. These groups are :—(1) Treatments B, C, H and I and (2) A, D, E, F, G and J.

(iii) *Green-manure and superphosphate experiments in the New Area, Waini Block.* The experiment was laid out in a Latin Square with five replications. The area of each plot was 1/10 acre ; oats B. S. I was grown in *rabi*.

Treatment per acre	Time of manuring	Mean yield of oats grain per plot in lb.	'z' test	't' test for mean difference
T. 1 Fallow .	..	131·8	Not significant.	T. 2 > T. 1 and T. 5 > T. 1 at the 5% level of significance.
T. 2 Fallow and superphosphate @ 80 lb. P ₂ O ₅ .	Super applied at the break of monsoon.	162·0		
T. 3 Sann-hemp .	..	134·6		
T. 4 Sann-hemp with superphosphate @ 80 lb. P ₂ O ₅ .	Super applied before sowing sann-hemp.	147·4		
T. 5 Sann-hemp with superphosphate @ 80 lb. P ₂ O ₅ .	Super applied before sowing oats.	162·8		

(iv) *Manurial experiments with sulphate of potash and muriate of potash on berseem seed production.* Berseem, one of the best fodder crops for milch cows in winter, is grown here from imported seed. Seed formation in berseem is very scanty in these parts though the plant flowers abundantly.

The experiment was started this year to see the possibility of bringing about seed formation by applying the following treatments :—

1. Sulphate of potash at 100 lb. per acre.
2. Sulphate of potash at 200 lb. per acre.
3. Muriate of potash at 100 lb. per acre.
4. Muriate of potash at 200 lb. per acre.

The experiment was laid down in two series—one received the above treatments in three doses while in the other series the treatments were applied in four doses.

The experiment is being continued.

(v) *Manurial experiments with superphosphate and oil-cake on sugarcane Co. 210 in the New Area, Block IV.* The lay-out of the experiment was a Latin Square with 4 replications and the area of each plot 1/18 acre. In all treatments, the total amount of super and half nitrogen were applied at planting and the other half of nitrogen in the middle of June. The P_2O_5 in the oil-cake was not deducted from the main dressing of super.

Treatment per acre	Sucrose % in juice (December)	Tonnage.		
		Mean yield per plot in lb.	'z' test	't' test for mean difference
T. 1—75 lb. P_2O_5	16.66	1,924.50	Significant at the 5% level	T. 2 and T. 3 > T. 1 at the 1% level and T. 4 > T. 1 at the 5% level. There is no significant difference between T. 2, T. 3 and T. 4.
T. 2—Do. + 40 lb. N	15.54	2,324.50		
T. 3—Do. + 60 lb. N	16.04	2,413.25		
T. 4—Do. + 80 lb. N	15.27	2,315.50		

(vi) *Manurial experiments with superphosphate and oil-cake on sugarcane Co. 210 in the New Area, Block IV.* The experiment was laid out in a Latin Square with four replications and the area of each plot 1/18 acre. In all treatments, super and half nitrogen were applied at planting and the other half of nitrogen in the middle of June.

Treatment per acre	Sucrose % in juice (December)	Tonnage		
		Mean yield per plot in lb.	'z' test	't' test for mean difference
T. 1—No manure	15.12	1,055.25	Significant at the 1% level.	T. 2, T. 3, T. 4 > T. 1 at the 1% level of significance. There is no significant difference between T. 2, T. 3 and T. 4.
T. 2—100 lb. P_2O_5 + 40 lb. N.	15.85	1,778.00		
T. 3—100 lb. P_2O_5 + 60 lb. N.	14.27	1,846.50		
T. 4—100 lb. P_2O_5 + 80 lb. N.	16.11	1,859.75		

(vii) *Manurial experiments with diammonphos and standard manure on sugarcane Co. 210 in the New Area, Bamboo Block.* The experiment was laid out in Beaven's half-drill-strip method with 11 replications; the area of each plot was 1/40 acre. Half diammonphos was applied at planting and half at ridging; standard manure, viz., 50 lb. P_2O_5 plus 40 lb. N, was applied at planting.

Treatment per acre	Sucrose % in juice (February)	Tonnage			
		Mean difference	Standard error	Critical difference	Result
T. 1—200 lb. diammonphos.	16.42	13.09 lb. in favour of diammonphos	16.03	35.71 (P. = .05)	Not significant.
T. 2—Standard manure (50 lb. P_2O_5 + 40 lb. N)	16.70				

(viii) *Manurial experiments with oil-cake on sugarcane Co. 210 in the New Area, Bamboo Block.* The treatments per acre were :—

- (1) 80 lb. nitrogen in two doses
- (2) 80 lb. nitrogen in one dose.

The lay-out of the experiment was Beaven's half-drill-strip method with 11 replications and the area of each plot was 1/40 acre.

Treatment	Sucrose % in juice (Feb- ruary)	Tonnage			
		Mean difference	Standard error	Critical difference	Result
T. 1—N in 2 doses	15.94	82.27 lb. in favour of 2 doses.	23.87	75.64 (P. = .01)	Highly signi- ficant.
T. 2—N in 1 dose.	16.02				

(ix) *Manurial experiments with sulphate of ammonia and nitrate of soda on sugarcane Co. 210 in the New Area, Bamboo Block.* The treatments per acre were :—

- (1) 80 lb. nitrogen as $(\text{NH}_4)_2\text{SO}_4$: Half nitrogen was given at the break of the monsoon and the other half after one month.
- (2) 80 lb. nitrogen as NaNO_3 : Half nitrogen was given at the break of the monsoon and the other half applied one month later.

The experiment was laid out in Beaven's half-drill-strip method with 15 replications ; the area of each plot was 1/40 acre.

Treatment	Sucrose % in juice (Jan- uary)	Tonnage			
		Mean difference	Standard error	Critical difference	Result
T. 1— $(\text{NH}_4)_2\text{SO}_4$	15.09	20.20 lb. in favour of NaNO_3 .	24.93	53.47 (P. = .05)	Not signifi- cant.
T. 2— NaNO_3	15.07				

2. VARIETAL YIELD TRIALS

(i) *Maize varietal trial for corn in North Pangarbi field.* The experiment was put in two separate Latin Squares ; a spacing of 18" within rows was tried in the one and 15" in the other lay-out. The distance between rows was kept at 2.5 feet in both cases. The area of each plot was 1/40 acre and the number of replications four.

Results of 18 inches spacing within rows

Varieties	Mean yield per plot in lb.	'z' test	't' test for mean difference
P. F. 1 . . .	39.11	Not significant.	Differences between the varieties are not significant.
P. F. 2 . . .	36.33		
P. F. 3 . . .	41.50		
Local . . .	36.67		

Results of 15 inches spacing within rows

Varieties	Mean yield per plot in lb.	'z' test	't' test for mean difference
P. F. 1 . . .	45.68	Significant at the 5% level.	P. F. 3 > P. F. 1 and P. F. 2 at the 5% level.
P. F. 2 . . .	44.15		
P. F. 3 . . .	51.54		
Local . . .	46.12		

(ii) *Varietal trial with maize for fodder in North Pangarbi field.* This experiment was also put in two separate Latin Squares ; the two different spacings tried were (1) 15 inches and (2) 12 inches within rows ; the distance between rows was 2.5 feet in both squares. The size of plot and number of replications were the same as in the previous experiment.

Results of 15 inches spacing within rows

Varieties	Mean yield per plot in lb.	'z' test	't' test for mean difference
P. F. 1 . . .	637.625	Not significant.	Not significant.
P. F. 2 . . .	604.875		
P. F. 3 . . .	592.500		
Local . . .	590.375		

Results of 12 inches spacing within rows

Varieties	Mean yield per plot in lb.	'z' test	't' test for mean difference
P. F. 1 . . .	724.625	Not significant.	P. F. 1 > P. F. 2 and local at the 5% level.
P. F. 2 . . .	671.375		
P. F. 3 . . .	697.500		
Local . . .	673.500		

(iii) *Varietal trial for seed with gram in North Pangarbi field.* This experiment was laid down in a Latin Square with 8 replications for each type. The area of a plot was 1/64 acre. The following are the results of the experiment :—

Types	Mean yield per plot in lb.	'z' test
T. 17	9.06	Significant at the 1% level.
T. 25	9.48	
T. 28	14.73	
T. 58	15.70	
P. F. 3	8.98	
P. F. 6	7.16	
P. F. 11	13.19	
P. F. 17	10.04	

't' test for mean differences :—

T. 58 > P. F. 17, T. 25, T. 17, P. F. 3 and P. F. 6

T. 28 > Do.

P. F. 11 > T. 25, T. 17, P. F. 3 and P. F. 6
at the 1 % level,

T. 58 > P. F. 17, T. 25, T. 17, P. F. 3 and P. F. 6

T. 28 > Do.

P. F. 11 > Do.

P. F. 17 > P. F. 6

at the 5 % level

and the differences between T. 58, T. 28 and P. F. 11 are not significant (at the 5 % level).

(iv) *Varietal trial with barley for grain in North Pangarbi field.* This experiment has been continued from 1930-31; the lay-out of the experiment this season was in Randomised Blocks. The plot area was 1/80 acre and number of replications eight.

The following are the results of the experiment :—

Varieties	Mean yield per plot in lb.	' z ' test	' t ' test for mean difference
T. 21 . . .	26.36	Significant at the 1% level.	T. 21 > C. 251, L. I and L. II at the 1% level.
C. 251 . . .	22.27		
Local I . . .	20.92		
Local II . . .	22.27		

3. EXPERIMENTS FOR OTHER SECTIONS OF THE INSTITUTE

(i) *Manurial experiments on sugarcane Co. 213 for the Imperial Agricultural Chemist in Nawabi field.* The experiment was laid out in a Latin Square with four replications to see the effect of different treatments on tonnage and sucrose content of the cane. The treatments per acre were as follows :—

T. 1—100 lb. N as mustard cake.

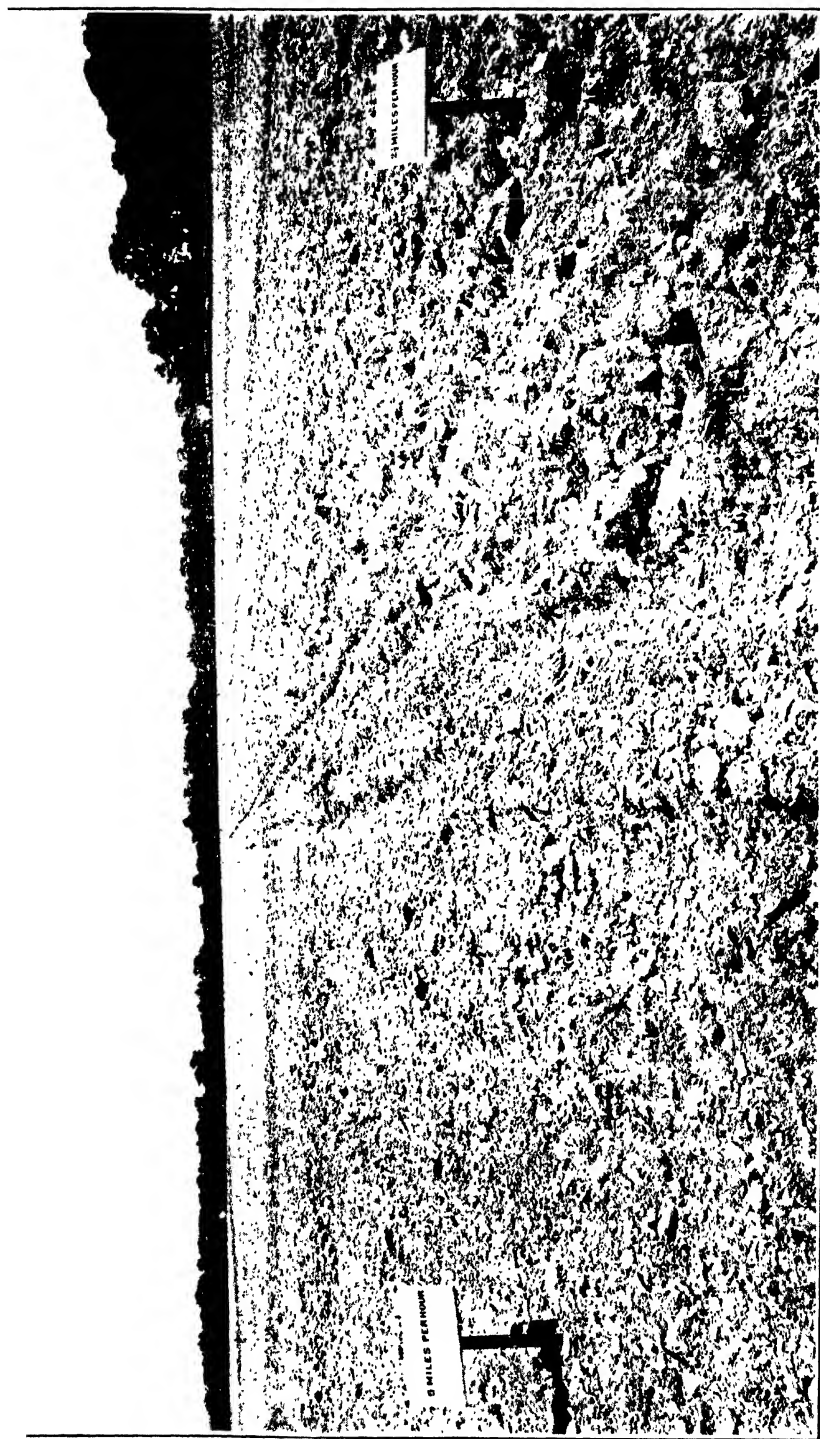
T. 2—100 lb. N + 50 lb. K_2O as K_2SO_4 .

T. 3—100 lb. N + 100 lb. P_2O_5 as superphosphate.

T. 4—100 lb. N + 50 lb. K_2O + 100 lb. P_2O_5 .

The results of the experiment will be dealt with by the Imperial Agricultural Chemist.

(ii) *Green-manuring experiments for the Imperial Agricultural Bacteriologist.* The experiment carried out during 1931-32 was repeated this year also on the same plots. In addition to this another green-manuring experiment was started on a larger scale. There were five treatments with five replications laid down in a Latin Square. The size of plots was 1/5 acre each. The following treatments were tried : (1) fallow, (2) *urid* green-manured, (3) soybean green-manured, (4) sann-hemp green-manured and (5) sann-hemp tops buried and fibre extracted from the stems. The results of these two experiments have been incorporated in the report of the Imperial Agricultural Bacteriologist.



Ploughing at 5 miles and $2\frac{1}{2}$ miles per hour on light land

(iii) *Varietal trial with wheat for the Imperial Agricultural Bacteriologist : P. 52 against country wheat.* The experiment was continued this year in old Jhilli. It was laid out in Beaven's half-drill-strip method with 17 replications. The size of plot adopted was 1/12 acre. The following are the results of the experiment :—

Varieties	Mean difference	Standard error	Critical difference	Results
Pusa 52 . . .	In favour of country wheat 4.45 lb.	2.92	6.18 (P. = .05)	Not significant
Country . . .				

(iv) *Tonnage experiment for the Imperial Mycologist with Co. 213 : mosaic versus mosaic-free cane.* The experiment was continued this year also in the silk house area ; the results of the experiment will be dealt with by the Imperial Mycologist.

4. MISCELLANEOUS EXPERIMENTS

(i) *Silage investigations.* Investigations with berseem silage were continued. Separate pits were filled with various mixtures on different dates and the wastage, moisture content and feeding value noted. The results have been written up in a separate note.

(ii) *Experiment to see the effect of speed of tractor-drawn implements on soil preparation and crop yields.* The experiment was laid down in Chhonia field in Beaven's half-drill-strip method with eleven replications for each treatment. Each strip measured 1,150 feet × 18 feet. Treatment No. 1 consisted of ploughing with a 5-furrow plough at seven inches on first speed at 2½ miles per hour and harrowing with Baron Tandem Disc Harrow on the same speed. The treatment No. 2 was ploughing with a 3-furrow plough at 7 inches on third speed at five miles per hour and harrowing with Roderic Lean Disc Harrow at the same speed. The "Vickers" tractor was used for the work.

The 5-furrow plough working at 2½ miles per hour left the furrows open and the furrow slice was not broken properly while the 3-furrow plough working at 5 miles per hour turned the furrows completely over, the furrow slice was pulverised thoroughly and the ploughed surface was smooth. The effect is clearly shown in the illustration given (Plate I). The time taken for ploughing was the same in both treatments.

Oats B. S. I was sown in *rabi* and the statistical results from its yield are given below proving that the higher speed does not affect tilth nor crop production :—

Treatment	Mean difference	Standard error	Critical difference	Results
T. 1—5-furrow plough at 2½ miles speed.	In favour of T. 2 = 9.59 lb.	12.435	27.705 (P. = .05)	Not significant
T. 2—3-furrow plough at 5 miles speed.				

(iii) *Spacing experiments with maize P. F. 2 for corn in North Pangarbi field.* The experiment was started to find out the most suitable spacing for maize within rows. Four different spacings—12, 15, 18 and 24 inches—were tried in a Latin Square with four replications; the distance between rows was kept at 2.5 feet. The size of each plot was 1/40 acre.

The following are the results of the experiment :—

Treatment	Mean yield per plot in lb.	'z' test	't' test for mean difference
T. 1—12 inches	48.06	Significant at the 1% level	T. 1 > T. 3 and T. 4
T. 2—15 inches	42.50		T. 2 > T. 4
T. 3—18 inches	38.68		T. 3 > T. 4 at the 1% level and also T. 1 > T. 2 at the 5% level
T. 4—24 inches	29.82		

(iv) *Sugarcane cutting experiment at Meghaul, District Monghyr.* As the data obtained from the cutting experiment of Co. 205 conducted last year on an area of two acres in Harpur Jhilli was not sufficient for working out the optimum plot size for sugarcane experiments, the present cutting experiment was undertaken this year. An area of 4.5 acres of Co. 213, the standard cane in North India, was kindly given for this purpose by Mr. C. Atkins, Manager, Dowlatpur Agricultural Concern, and with his assistance the cutting

was completed. The whole area of 4.5 acres was cut into 1,088 plots—each consisting of a single row 3 feet wide and 60 feet in length. The results of the experiment will appear in a separate publication.

VII. SUGARCANE VARIETAL WORK

The tremendous impetus given to the sugar industry by the extensive grant of protection has brought work on cane into greater prominence than ever before. The enormous increase in cane cultivation caused by the almost universal drop in the prices of all other crops has brought to the front several other problems which until the year under report were not regarded as pressing. The great extension of the crushing season has made it clear that the industry needs not only an early cane but also a late one and at present a great deal of money is being wasted in purchasing cane which has gone back in quality through being unable to stand into April and May. At Pusa this need was foreseen and we are now in the third year of experiments with a cane of this type. Work on Co. 281, as a cane suitable for irrigated areas under factory control, has now reached an estate scale and some 12 acres have been planted under this cane for a large scale test which, it is hoped, will definitely show that an increased amount of sugar per acre over the standard variety now irrigated can be obtained in a normal crop.

The following varieties were planted on a field scale during 1932-33 :—Co.'s 210, 213, 214, 281, 285, 299, 300, 301, 302, 303, 304, 312, 313, 316, 317, 318, 319, 322, 326, 331, 335 and 337.

The following varieties were under multiplication in the nursery :—Co.'s 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349 and 350. Sorghum hybrids 351, 352, 353, 354, 355, 356 and 357.

The following varieties were under observation in the nursery :—Tuc. 393, Tuc. 472, P. O. J. 2878. Imported in 1932 :—Co.'s 381, 382, 384, 386, 387, 388, 393, 395, 396 and 397.

The following varieties were rejected in 1932-33 for 1933-34 planting :—Co.'s 300, 301, 302, 312, 316, 317, 318, 319, 326, 335, 340, 341, 342, 345, 346, 349, 351, 352, 353, 354, 355, 356, 357 and P. O. J. 2878.

The following varieties were planted during February 1933 :—

(i) *Field-scale trial* :—Under varietal tests—Co.'s 210, 213, 214, 281, 285, 299, 303, 304 (under observation), 313, 322, 331, 337, 339, 343 and 344.

(ii) *Small-scale trials* :—Under multiplication in the New Area nursery—

(a) Varieties imported from Coimbatore in 1930 :—Co.'s 347, 348, 350, 393, Tuc. 393 and Tuc. 472. (Co. 338 under observation at Sericulture area).

(b) Varieties imported from Coimbatore in 1932 :—Co.'s 381, 382, 384, 386, 387, 388, 393, 395, 396 and 397.

(c) Varieties imported from Coimbatore in 1933 :—Co.'s 360, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381*, 382*, 383, 384*, 385, 386*, 387*, 388*, 389, 390, 391, 392, 393*, 394, 395*, 396*, 397*, 402†, 408†, 412†, 413†, 417† and 419†.

SUGARCANE VARIETAL TEST

In addition to the standard varieties we have now the following canes in reserve which have completed their tests and are being examined for minor points as to their suitability for various areas—Co. 299, Co. 313, Co. 331 and Co. 285. Co. 299 is practically as early as Co. 214 and far superior to it in tonnage as proved by the experiments conducted last year. Co. 313 is another promising early variety which has yet to obtain a clear certificate from mosaic before any further advance can be made towards distribution. Co. 331 represents the late cane required for April and May crushing. It is of high tonnage and can stand much longer in the field without deterioration than any other variety now grown on an extensive scale in the tract. Co. 285 represents the most suitable cane for water-logged areas but the distribution of this cane has now been suspended as ample supplies of Co. 210 and Co. 213 are available to the mills and the extension of cane growing to poor land is no longer required.

Another problem of great importance to cane growers is the question of the preservation of seed of *early* canes of the Co. 214 type in the field as great damage is done to the seed-cane crop by jackals and much damaged seed has to be planted. The trashing of such early canes for seed has been successfully accomplished and the entire experiment has been written up for publication separately. Further work on this line is now in progress. Co.'s 303 and 322 are liable to lodge badly but they have been retained for the present to see the effect of interlocking experiments with Co. 213 in preventing lodging.

Co.'s 337, 338, 343, 344 and 304 are still under observation.

*Repeats.

†Thick canes.

The analysis results of the above varieties of canes are given below :—

Serial No.	Sugarcane varieties	Sucrose per cent. in juice			
		October, 1932	November, 1932.	December, 1932	January, 1933
1	Co. 210 . .	..	15.43	15.58	15.71
2	Co. 213 . .	..	13.59	14.50	17.39
3	Co. 214 . .	14.27	13.49	17.68	17.42
4	Co. 281 . .	12.76	14.25	18.23	..
5	Co. 285. . .	..	14.66	14.55	16.51
6	Co. 290 . .	14.73	15.63	17.92	18.26
7	Co. 303 . .	..	11.10	14.91	16.70
8	Co. 304 . .	..	12.64	13.66	15.05
9	Co. 313 . .	12.71	17.23	18.13	17.87
10	Co. 322 . .	..	12.62	16.03	18.21
11	Co. 337 . .	..	14.30	16.92	18.00
12	Co. 338 . .	..	16.43	17.25	17.62
13	Co. 339 . .	..	13.61	14.74	17.15
14	Co. 343 . .	..	13.58	15.08	16.08
15	Co. 344 . .	..	15.48	16.55	16.50

Analysis of Co. 331 as a late ripening cane is given subsequently.

REJECTION OF SUGARCANE VARIETIES

Co.'s 300, 301 and 302 were rejected as they failed to compete successfully with our early and mid-season standard varieties. Co. 312, which is one of the heaviest yielders, lodges very badly and is quite unable to stand in the field after September and has therefore to be discarded. Co. 316 was discarded for tonnage, while Co.'s 317, 318 and 319 which were of the Co. 285 type were found inferior to this cane and rejected. Co. 326 was very badly lodged and was of poor sucrose and tonnage. Co. 335 showed very poor growth and was of exceedingly low tonnage. Co.'s 340, 341, 342, 345, 346 and 349 were rejected on account of bad agricultural habit. Co. 351 to Co. 357, sorghum hybrids, were expected to ripen in six months' time from the date of planting, and to supply

the mill with canes at a time when normal canes were not available, thus reducing the overhead charges of the mill by enabling it to work throughout the year, but since these varieties have failed to fulfil this desired object, they were rejected as useless to the tract. P. O. J. 2878 has been finally discarded on account of stunted growth and bad agricultural habit.

RESULTS OF FIELD EXPERIMENTS CONDUCTED WITH DIFFERENT SUGARCANE VARIETIES

(i) *Varietal trial with sugarcane for tonnage in Phatak field.* The experiments were laid out in Beaven's half-drill-strip method with 15 replications; the plot area was 1/24 acre each. The following are the results of the experiments :—

Varieties	Sucrose % in juice (January)	Tonnage			
		Mean difference	Standard error	Critical difference	Results
Co. 210 .	15.43	In favour of Co. 331 = 113.45 lb.	44.297	95.017 (P. = .05)	Significant at the 5% level.
Co. 331 .	15.30				
Co. 210 .	15.56	In favour of Co. 213 = 34.83 lb.	43.32	92.92 (P. = .05)	Not significant
Co. 213 .	14.61				
	Sucrose % in cane (November)				
Co. 214 .	15.36	In favour of Co. 299 = 335.26 lb.	43.02	128.07 (P. = .01).	Significant at the 1% level.
Co. 299 .	15.63				

Co. 331 is a cane of good agricultural habit but appears to be a late ripening variety as will be seen from the chemical analyses of juice carried out on different dates and therefore likely to be of value to the grower for late harvesting.

Date of analysis	Sucrose per cent. in juice	
	Co. 331	Co. 210
6th January 1933	15.30	15.43
17th February 1933	15.16	15.65
16th March 1933	17.78	15.19
16th March 1933	16.03	16.06
3rd April 1933	17.16	15.30
3rd April 1933	16.47	15.98
11th April 1933	17.40	17.68
11th April 1933	18.64	17.22
18th April 1933	18.36	13.50
18th April 1933	16.45	14.90
25th April 1933	17.67	14.31
25th April 1933	17.06	15.60
4th May 1933	18.53	14.91

From these analyses it would appear that Co. 331 is definitely able to stand on when Co. 210 has gone back completely and will pay to grow for late season crushing.

(ii) *Preliminary trial with new Co. cane varieties for tonnage in Phatak field.* The trial was conducted on the "chess-board" system with 16 replications for each variety. The plot area taken was 1/40 acre. The results of the experiment are given below:—

Varieties	Sucrose % in juice (December)	Tonnage		
		Mean yield per plot in lb.	'z' test	't' test for mean difference
Co. 300	14.73	994.09	Significant at the 1% level.	Co. 312 > Co.'s 300, 301, 302, 316 and Co. 301 > Co.'s 300, 302 and 316 at the 1% level.
Co. 301	13.69	1,228.03		
Co. 302	13.12	1,064.94		
Co. 312	11.08	1,456.50		
Co. 316	13.89	979.81		

(iii) *Varietal trial with sugarcane for tonnage in the New Area, Block IV.* The three standard varieties of cane Co.'s 210, 213 and 214 were tried with Co. 281 in a Latin Square with 4 replications. The plot area was 1/30 acre. The following are the results of the experiment :—

Varieties	Mean yield per plot in lb.	'z' test	't' test for mean difference
Co. 210 . . .	1,179.50	Significant at the 5% level.	Co. 210 > Co. 281 at the 1% level and Co. 210 > Co. 213, Co. 281; Co. 214 > Co. 281 at the 5% level.
Co. 213 . . .	850.25		
Co. 214 . . .	996.00		
Co. 281 . . .	752.50		

(iv) *Trashing of Co. 281 for seed.* The chief difficulty of growing Co. 281 or any other early ripening cane is the damage caused to the seed-cane by jackals and pigs when left standing in the field for seed after the harvesting of the main crop. The trashing of this cane for seed purpose was tried this year also in the New Area and Phatak with great success. The following are the variations in the chemical analyses of juice of trashed and fresh canes :—

Description	Date of analysis	Average weight of cane in lb.	Juice %	Sucrose %	Purity %
1. Co. 281 fresh .	21st Dec. 1932.	2.25	66.11	18.23	87.60
2. Co. 281 trashed on 20th Dec. 1932.	21st Jan. 1933.	1.30	61.50	15.40	79.18
3. Do. .	31st Jan. 1933.	1.43	70.93	19.01	82.40
4. Do. .	31st Jan. 1933.	1.35	62.96	17.75	80.63
5. Co. 281 trashed on 10th Jan. 1933.	21st Jan. 1933.	2.10	64.29	18.12	85.88
6. Do. .	31st Jan. 1933.	1.93	65.52	18.36	82.18

It was found that the trashed canes suffer a loss of about 20 per cent. in weight in 55 days. Germination of trashed setts was one week later than the short-planted setts. Laboratory tests showed the germination percentage to be 61 per cent. for trashed and 98 per cent. for short-planted cane. Though the short-planted canes had a better start at the beginning, the deficiency was made up by the trashed canes after the break of rains in April and now there is practically no difference in growth between them.

VIII. MISCELLANEOUS CROPS GROWN FOR THE SECTIONAL OFFICERS OF THE INSTITUTE

(1) The following improved varieties of crops were grown for the Imperial Economic Botanist in the Agricultural Section for seed multiplication. The average yield of each variety per acre is given below :—

Serial No.	Field	Crops	Area in acre	Yield per acre in mds.	Remarks
1	Gonhri .	Wheat P. 4 .	10.00	13.05	Somewhat affected by frost.
		Wheat P. 12 .	9.00	16.25	Do.
		Wheat P. 52 .	10.00	15.99	Do.
		Barley T. 21 .	10.00	29.47	..
2	Jhilli .	Gram T. 25 .	5.00	9.56	..
		Gram T. 58 .	3.00	11.92	..
		Gram T. 17 .	4.00	8.83	..
3	Mysore .	New Hibiscus .	5.00	} Partly cut for seed and fibre by B. S. and partly buried by Farm.	Sown broad cast.
		New Hibiscus .	5.00		Sown with drill.
		Arhar T. 80 .	9.50	1.63	Affected by frost.
4	Nepauli .	Lentil T. III-86	1.00	6.82	..
		Linseed T. 121.	1.00	4.32	..
		Linseed T. 124.	1.00	4.03	..
		Linseed T. 12 .	1.00	7.00	..
5	Punjab— D Block	Wheat P. 111 .	6.00	5.93	Greatly affected by frost.
6	Punjab— B Block	Arhar eight varieties.	8.00	5.28	Do.

(2) The following crops were grown in small plots for the study of insect pests by the Imperial Entomologist :—

Kharif—Soybean, maize, til (*Sesamum indicum*), sunflower, mung (*Phaseolus radiatus*), castor, bajra (*Pennisetum typhoides*) and juar (*Andropogon Sorghum*).

Rabi—Sugarcane Co. 210, Co. 213, Co. 281 and Co. 285, peas, gram, wheat, linseed, chillies, tobacco, safflower, mustard and lentil.

IX. MACHINERY

(1) STEAM PLOUGHING TACKLE AND TRACTORS

The steam ploughing tackle was stood off almost completely during the year as a matter of economy. All main cultivation operations were done with tractors except the preliminary run by steam tackle before *rabi* preparations. The Marshall 15/30 H. P. fuel Diesel tractor which was purchased in March 1932 was given a full trial. Working costs and analysis of operations are given in the statement below as compared with the three other tractors worked during the year. The Lanz Bulldog tractor is in its third year, the International in its sixth year and the Vickers in its fourth year. To compare the Marshall tractor with the International, the first year's working details of the latter are also given :—

Cost per acre

Name of tractor	Ploughing	Disc harrowing	Grubbing
	Rs. a. p.	Rs. a. p.	Rs. a. p.
Marshall	1 12 9	0 14 0	0 13 3
International	2 12 0	1 6 5	1 7 2

These figures clearly show that with all points taken into consideration the crude oil principle in agricultural machinery of all kinds has definitely come to stay, and no tractor owner can afford, in these days of low prices for produce, to neglect the obvious method shown above for reducing costs.

The results of the year's working have shown that the crude oil tractor is as easy to start, manipulate and work as any kerosene oil tractor. De-coking which is required by these crude oil models after every 50 hours running is a very simple process, takes about six hours and can be done by any mistry after brief instructions.

The oil air cleaner and provision of cylinder liner in the Marshall tractor are distinct improvements over the Lanz Bulldog which has a dry air cleaner and no cylinder liner.

A report dealing with the actual comparisons of crude oil and kerosene oil tractors working will be published separately.

I. Statements showing the output, consumption and cost of cultivation by tractors for the year 1932-33.

(a) Output

Summary of the work done												
Serial No.	Name of tractor	Working hours	Summary of the work done									
			Ploughing		Disc harrowing		Grubbing		Rolling		Drilling	
			Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres
1	Marshall Fuel Diesel 15/30 H. P.	460.79	165.54	161.89	91.75	183.38	125.59	263.83	6.50	25.38	71.50	217.00
2	Lanz Bulldog semi Diesel 15/30 H. P.	316.50	97.75	80.15	54.75	105.50	96.00	192.59	68.00	248.50	..	..
3	McCormick Deering 15/30 H. P.; K. Oil.	104.25	50.50	50.82	37.75	83.08	16.00	40.46	..	..	..	..
4	Vickers 23/40 H. P.; K. Oil.	346.75	39.75	58.57	304.50	676.05	..	..	2.50	9.62	..	..
Serial No.	Name of tractor	Working hours	Acreage per hour									
			Ploughing		Disc harrowing		Grubbing		Rolling		Drilling	
			Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres
1	Marshall Fuel Diesel 15/30 H. P.	460.79	0.97	1.99	1.99	1.99	2.10	3.60	3.60	3.03	..	..
2	Lanz Bulldog semi Diesel 15/30 H. P.	316.50	0.82	1.92	1.92	1.92	2.00	3.65	3.65	..	..	..
3	McCormick Deering 15/30 H. P.; K. Oil.	104.25	1.00	2.20	2.20	2.20	2.52	..	..	..	..	..
4	Vickers 23/40 H. P.; K. Oil.	346.75	1.47	2.22	2.22	2.22	..	3.84	3.84	..	..	..

(b) Consumption

Name of tractor	Working hours	Fuel						Engine and Gear Oil		Grease	
		Crude Oil		K. Oil		Petrol		Total gallons	Per hour gallons	Total lb.	Per hour lb.
		Total gallons	Per hour gallons	Total gallons	Per hour gallons	Total gallons	Per hour gallons				
Marshall Fuel Diesel 15/30 H. P.	460.79	714.40	1.53	17.11	0.03	..	..	89.60	0.19	79.00	0.17
Lanz Bulldog semi Diesel 15/30 H. P.	316.50	504.44	1.59	13.67	0.04	..	..	60.41	0.19	52.75	0.16
McCormick Deering 15/30 H. P.; K. Oil.	104.25	..	..	267.08	2.56	10.16	0.09	22.82	0.22	17.59	0.16
Vickers 23/40 H. P.; K. Oil	346.75	..	..	1,181.38	3.40	24.41	0.07	91.26	0.26	67.59	0.19

	Waste	
	Total lb.	Per hour lb.
Marshall Fuel Diesel 15/30 H. P.	..	..
Lanz Bulldog semi Diesel 15/30 H. P.	..	..
McCormick Deering 15/30 H. P.; K. Oil	..	..
Vickers 23/40 H. P.; K. Oil	..	..
	32.37	0.07
	25.25	0.08
	17.01	0.16
	31.49	0.09

(c) Cost

Serial No.	Name of tractor	Working hours	Analysis of total cost					Spare parts and sundry stores
			Wages of the mistries and water carriers	Kerosene oil	Crude oil	Petrol	Lubricants	
1	Marshall Fuel Diesel 15/30 H. P.	460.79	Rs. a. p. 103 4 11	Rs. a. p. 11 7 9	Rs. a. p. 354 9 1	Rs. a. p. ..	Rs. a. p. 266 11 8	Rs. a. p. 10 5 0
2	Lanz Bulldog semi Diesel 15/30 H. P.	316.50	44 11 2	9 1 9	248 4 6	..	175 15 11	23 13 5
3	McCormick Deering 15/30 H. P.; K. Oil.	104.25	16 0 4	176 7 0	..	16 6 9	52 0 7	203 8 0
4	Vickers 23/40 H. P.; Kerosene oil.	346.75	63 4 0	787 5 3	..	39 2 10	238 13 3	914 8 4

Analysis of total cost			
Repairing staff and miscellaneous wages		Total	Expenses per hour
Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
1. Marshall Fuel Diesel 15/30 H. P.	67 3 1	813 9 6	1 12 2
2. Lanz Bulldog semi Diesel 15/30 H. P.	93 6 4	803 5 1	2 8 5
3. McCormick Deering 15/30 H. P.; K. oil	40 1 0	504 7 8	4 13 5
4. Vickers 23/40 H. P.; kerosene oil	165 14 1	2,308 15 9	6 5 11

(d) Cost per acre

Serial No.	Name of tractor	Ploughing	Disc harrowing	Grubbing	Rolling	Drilling
		Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
1	Marshall Fuel Diesel 15/30 H. P.	1 12 9	0 14 0	0 13 3	0 7 2	0 9 3
2	Lanz Bulldog semi Diesel 15/30 H. P.	3 1 5	1 5 0	1 4 1	0 11 0	..
3	McCormick Deering 15/30 H. P.; kerosene oil	4 13 5	2 3 2	1 14 6	..	..
4	Vickers 23/40 H. P.; kerosene oil	4 5 1	2 13 11	..	1 10 4	..

II. Statement showing the consumption and expenses of the tractors for belt pulley work for the year 1932-33

Name of tractor	Working hours	K. oil		Petrol		Crude oil		Lubricating oil	
		Total gallons	Per hour gallons	Total gallons	Per hour gallons	Total gallons	Per hour gallons	Total gallons	Per hour gallons
McCormick Deering	128.25	265.80	2.072	10.00	0.077	..	..	29.96	0.233
Cost	..	Rs. a. p. 176 2 9	..	Rs. a. p. 16 2 0	..	..	..	Rs. a. p. 61 9 2	..
Vickers	68.75	171.61	2.496	6.50	0.094	..	..	17.665	0.256
Cost	..	Rs. a. p. 112 9 9	..	Rs. a. p. 10 9 0	..	..	..	Rs. a. p. 37 13 1	..

	Grease		Waste	
	Total lb.	Per hour lb.	Total lb.	Per hour lb.
McCormick Deering	24.00	0.187	7.12	0.055
Cost	Rs. a. p. 4 15 4	..	Rs. a. p. 0 14 11	..
Vickers	15.00	0.218	5.87	0.085
Cost	Rs. a. p. 2 13 0	..	Rs. a. p. 0 11 9	..

Name of tractor	Working hours	Spare parts and sundry stores	Wages of the mistries and water carriers	Repairing staff and miscellaneous wages	Total expenses	Expenses for running per hour
McCormick Deering	128.25	Rs. a. p. 250 7 5	Rs. a. p. 22 3 2	Rs. a. p. 49 4 0	Rs. a. p. 581 10 9	Rs. a. p. 4 8 6
Vickers	68.75	181 4 8	12 13 10	32 15 0	391 10 1	5 11 1

III. Working details of the McCormick Deering tractor during 1927-28 (the 1st year of working)

Working hours	Ploughing per hour	Disc harrowing	Grubbing	K. oil consumed per hour	Cost of spare parts	Expenses per hour
291.30	Acre 9.87	Acre 1.71	Acre 1.65	gallons 1.61	Rs. a. p. 13 15 7	Rs. a. p. 2 6 5

Cost per acre

Ploughing	Disc harrowing	Grubbing
Rs. a. p. 2 12 0	Rs. a. p. 1 6 5	Rs. a. p. 1 7 2

NOTE.—In the first year we had no four-furrow ploughs and a three-furrow plough was used.

2. THRESHER

Investigations dealing with the design of a small thresher suitable for Indian conditions at a price within the range of small land-owners were concluded. The new thresher fitted with a completely redesigned type of drum was given an exhaustive test and proved itself in every way suitable. The daily output is given below :—

Date	Time	Yield	Yield per hour
	Hours	Mds.	Mds.
25th March 1933 . . .	3·250	14·481	4·455
26th March 1933 . . .	3·283	17·178	5·232
27th March 1933 . . .	2·716	12·745	4·692
28th March 1933 . . .	4·166	15·993	3·839
29th March 1933 . . .	3·800	16·937	4·457
30th March 1933 . . .	4·016	11·525	2·869
31st March 1933 . . .	2·650	8·450	3·188
1st April 1933 . . .	2·883	7·550	2·618
2nd April 1933 . . .	3·366	11·479	3·410
3rd April 1933 . . .	3·700	11·807	3·191
4th April 1933 . . .	2·815	9·035	3·209
5th April 1933 . . .	4·330	18·575	4·286
6th April 1933 . . .	4·350	16·850	3·873
7th April 1933 . . .	3·566	22·443	6·293
8th April 1933 . . .	4·416	22·225	5·032
9th April 1933 . . .	4·283	21·587	5·040
	57·590	238·860	..

Average per hour :—4·15 maunds.

The entire experiment has been written up for publication separately.

The design for a standard bullock gear to work the above thresher was remodelled and further tests are in progress. It is hoped to bring out the entire outfit at a price within Indian limits.

X. CATTLE BREEDING

The pedigree Sahiwal herd stood at 227 head during the year under report. The remainder of the cross-bred stock, with three exceptions were disposed of (Appendix—Table I).

It is of considerable interest to note that the quarter-bred stock ($\frac{3}{4}$ Sahiwal and $\frac{1}{4}$ Ayrshire) sired by bull Cello No. 23, the stud bull of this herd in 1919, has proved of very high milking quality; one cow now at Hosur having given 13,083 lb. to-date (500 days) in her second lactation and one cow now in the third lactation at Pusa giving 32 lb. per day from three quarters at 83 days.

This line of work appeared very promising as the stock is good all round and appears little affected by disease or climatic conditions, and its cessation is regretted.

Table II in the Appendix shows the total yield of milk from the herd and the method of its disposal during the year under report. Owing to the disposal of the remainder of the cross-breds, the herd produced 54,297 lb. less milk. This decrease in the total milk yield had its effect on the production of cream, *ghee* (clarified butter) and skim milk.

During the season, the local price of milk was reduced very considerably and this affected the sale of this product from the dairy—a large number of our Indian customers preferring an impure article at a cheaper rate, as a result less milk was sold from the herd.

The special calf feeding experiments in relation to early maturity account for the large increase in the amount fed to calves. Rations for bad doers and weak animals in the herd account for the increased issue of milk for medicinal purposes.

The most noticeable point regarding the Pusa Sahiwal herd during the year under report has been the increase in the milk yield of the herd. The new system of feeding and handling referred to in the last report was worked throughout the year and the yield of the herd per cow per day was raised from 13.6 to 17.9 lb. and the percentage of cows in milk increased from 50.2 to 55.1 (Appendix—Table III).

The first year's results of this experiment have been written up and will be published. Briefly recapitulated, they are: (i) increase in the total milk yield of the herd by 47 per cent., (ii) a reduction in the cost per lb. of milk, (iii) a reduction in the amount of concentrates fed, (iv) no increase in the general expenses of the herd, (v) a reduction in the service period; (vi) a steady rise in weight after milking condition had been reached; and (vii) a steady maintenance of the average fat percentage of 4.7 in the milk yield throughout.

During the year under report, the herd milch record, which had stood for ten years, was beaten by five cows, while the heifer record was passed by two heifers—the highest lactation being 8,863 lb. in 304 days for cows, and 7,648 lb. in 304 days for heifers, the herd record being 7,053 lb. in 303 days previously (Appendix—Table IV).

In order to get some line of comparison with other pedigree herds which do not adhere rigidly to the 304 days' lactation period, as practised in this herd, Sahiwal cow Chengi No. 534 was allowed to pass over the fixed period and has done 9,746 lb. to date in 447 days and is giving 12 lb. daily.

Despite the general drop in the price of cattle throughout India no difficulty was experienced in disposing of surplus stock at good prices. The demand for good pedigree stock is still very great and the herd has a waiting list of orders for cows and stud bulls at high prices.

Calf rearing. During the year under report the special system for obtaining early maturity with pail-fed calves was carried on. Marked gains in body weight and more rapid maturity were observed, while the calf mortality figures are given below and show the effect on the general health of the pail-fed calves for the period of the experiment (Appendix—Table V).

XI. PROGRAMME OF WORK FOR 1933-34

1. Cultivation investigations with special reference to production of tilth and condition of soil associated with speed of implements.

2. Green-manuring investigations with special reference to water requirements in various soils and conditions required by different crops.

3. General treatment of a 600-acre farm with special reference to reduction of costs in cultivation and the rotations suitable to the introduction of machinery.

4. Line-breeding investigations with a pedigree herd of Sahiwal cattle with special reference to the transmission of milch characters.

5. Experiments on feeding and digestion trials in collaboration with the Physiological Chemist to determine the digestive capacity of Indian cattle.

6. Special feeding of young calves with a view to early maturity to lengthen the profit period of the average Sahiwal cows and the bulls.

7. Investigation of the threshing problem in India and the design of a small threshing plant to suit all-India requirements.



8. Experiments with various types of motor tractors and general tractor implements for collection of data and determination of most suitable types of tractors and implements for Indian conditions.

Collaboration with manufacturers with regard to the manufacture and test of new types of implements built to correlate with present tractor design.

9. Investigations on silage problems.

10. Experimental work—

(a) The design, lay-out and general technique connected with modern field experiments.

(b) Trials of new varieties of crops.

(c) Manurial experiments.

(d) Trials of sugarcane varieties suitable for growth without irrigation for various classes of soils and with ripening dates corresponding to the alteration in factory conditions.

(e) Rotational experiments.

(f) Crop experiments in collaboration with Sectional Officers.

11. Training of post-graduate students.

12. Touring and advisory.

XII. PUBLICATION

Sayer, M. Wynne.....Soybean (*Glycine hispida* Maxim.).
Agri. and Live-stock in India, III, 5 (September, 1933).

APPENDIX

TABLE I

Annual statement of live-stock as it stood on the 30th June, 1933

[illegible]

8	Do.	Young female stock	..	..	..	..	..	..	..	..
9	Miscellaneous crosses	Bull	..	..	..	..	..	..	..	..
10	Do.	Cow	1	..	..	..	..	..	..	1
11	Do.	Young male stock	15	1	..	7	8	1	..	1
12	Do.	Young female stock	10	1	..	10	..	1	..	1
13	Cart bullocks	..	5	..	..	..	..	5	..	5
Total			247	86	30	..	7	28	81	20
1	Sheep	Male stock	25	19	..	16	..	5	..	23
2	Do.	Female stock	46	14	..	..	..	5	..	55
Total			71	33	..	..	10	..	16	78

TABLE II

Statement showing total milk yield and its disposal for 1932-33

Month.	Total milk yield	Disposal						Cream			Ghee			Skin-milk												
		Issued for			Total	lb.	Shortage	oz.	Sold	Converted into ghee	oz.	Shortage	oz.	Sold	Other- wise dis- posed	lb.	Quantity obtained	lb.	Red to calves	lb.	Red to cattle	lb.	Misc. disposal	lb.		
		Medicine	Analysls	Cream																					Calves	Thrown or split
1932.																										
July	27,124	14,441	5	39	6,534	5,679	39	27,124	7,925	447	7,475	3	3,908	..	6,144	275	3,043	2,823	1	2,823	1					
August	27,841	14,241	171	37	7,427	5,853	72	27,841	8,622	546	8,076	..	6,960	..	6,590	256	2,443	3,888	3	3,888	3					
September	26,590	13,663	324	304	6,533	5,604	46	26,590	7,771	487	7,282	22	7,400	88	6,098	311	2,582	3,201	4	3,201	4					
October	24,798	10,977	372	24	5,707	7,927	10	24,798	6,680	655	5,966	9	7,344	56	5,078	459	1,994	2,682	4	2,682	4					
November	22,555	10,990	776	394	3,352	7,295	26	22,555	3,682	714	2,957	11	5,360	40	2,968	341	1,418	1,200	9	1,200	9					
December	22,112	10,208	969	35	4,550	6,259	8	22,112	5,216	795	4,417	4	858	16	4,046	355	1,800	1,890	1	1,890	1					
1933.																										
January	19,770	9,757	827	48	1,831	7,166	13	19,770	1,983	1,091	884	8	3,116	160	1,591	296	678	614	3	614	3					
February	17,438	8,467	635	27	1,243	6,928	11	17,438	1,378	685	683	10	164	..	1,038	250	656	125	1	125	1					
March	21,707	10,413	696	33	1,559	8,909	11	21,707	1,726	559	1,152	15	492	..	1,328	359	869	86	14	86	14					
April	22,697	10,899	497	33	2,288	10,204	4	22,697	2,439	649	1,821	19	452	..	2,006	461	1,092	487	16	487	16					
May	32,569	11,477	508	42	9,995	10,515	5	32,569	11,047	569	10,477	1	574	..	8,991	419	3,846	4,722	4	4,722	4					
June	33,479	11,525	240	48	9,337	12,229	17	33,479	10,091	1,061	9,028	2	2,214	..	8,473	495	3,149	4,827	2	4,827	2					
Total	299,990	137,051	6,021	441	60,956	94,269	263	299,990	68,560	8,258	60,198	104	38,842	360	54,351	4,279	23,510	26,500	62	26,500	62					
Total for 1931-32.	854,237	180,006	134	158	89,776	82,831	204	854,237	1,01,191	10,753	90,304	134	32,300	44	80,504	3,434	32,091	44,964	144	44,964	144					

TABLE III

Statement of milk yield of Sahiwal cows for 1932-33

Month	Sahiwal cows					Percentage in milk	
	Yield	Average yield per day	Average yield per cow per day	No. of cows in milk and dry			
				Total No.	In milk		Dry
July 1932	21,992	709	17.7	81	40	41	49.4
August	24,198	781	18.6	82	42	40	51.2
September	23,755	792	18.0	82	44	38	53.7
October	23,295	751	17.1	75	44	31	58.7
November	21,379	713	16.6	75	43	32	57.3
December	20,785	670	17.6	70	38	32	54.3
January 1933	18,802	697	17.3	68	35	33	51.5
February	16,973	696	17.8	74	34	40	45.9
March	21,543	695	17.8	78	39	39	50.0
April	23,480	783	17.8	78	44	34	56.4
May	30,730	991	19.1	80	52	28	65.0
June	31,110	1,037	19.2	80	54	26	67.5
Average per month	23,170	761	17.9	77	42	35	55.1
Average for 1931-32	16,617	545	13.6	79	40	39	50.2

TABLE IV

Milk record for the Sahiwal herd and heifers, 1932-33

Name of cows and heifers		Best lactation in lb.	Days	Previous best lactation in lb.	Days
Cows—	1. Ramati . . .	8,863	304	5,066	306
	2. Chandrika . . .	8,081	305	5,465	304
	3. Ajbi . . .	8,060	306	4,014	303
	4. Chengi* . . .	7,901	304	6,681	304
	5. Mukta . . .	7,254	306	5,536	304
	6. Makhi . . .	7,226	306	5,478	303
	7. Lakhni . . .	7,017	304	5,582	305
Heifers—	8. Laruli . . .	7,648	304	..	..
	9. Lalagi . . .	7,019	306	..	..
	10. Bansuri . . .	5,034	306	..	..

*She has done 9,746 lb. to-date (447 days) and is giving 12 lb. at present.

NOTE :—Previous herd record :—Kamli 7,053 lb. in 306 days (1926).

Previous heifer record :—Kamli 5,785 lb. in 304 days (1921).

TABLE V

Sahiwal calf mortality figures

(Pail-fed period)

Period	No. of calves	Mortality per cent.
April 1931, to March 1932	70	4.3
April 1932, to March 1933	69	1.4

REPORT OF THE IMPERIAL ECONOMIC BOTANIST

(F. J. F. SHAW, D.Sc., A.R.C.S., F.L.S., I.A.S.)

(1) BOTANICAL SECTION, PUSA

I. ADMINISTRATION

Dr. Shaw held charge of the Section throughout the year under report. Mr. Kashi Ram continued to officiate as Assistant Economic Botanist. The post of Special Research Assistant was sanctioned for another year and Mr. R. D. Bose continued to hold it. The post of Second Economic Botanist remained vacant.

A sum of about Rs. 1,573 was realized mostly from the sale of improved seeds. Most of the work of multiplying and distributing seed of improved types of crops was carried out on the Pusa Farm in collaboration with the Imperial Agriculturist.

TRAINING

Three students completed their post-graduate training in this Section in October 1932. All three rendered material help in the different problems to which they were attached.

Mr. S. Majid, B.Sc., continued to receive his training during the year under report and six students joined the post-graduate course in November 1932.

In the first week of March all the students of this Section were sent to the Botanical Sub-station at Karnal for about a week to study the growth of crops under the irrigation conditions which are typical of northern India.

Three students from the Agricultural Section were permitted to attend the course of lectures delivered in this Section in genetics, biometry and statistical methods as applied to field trials.

A special course of training in the flue-curing of tobacco was instituted this year and although there were a number of applicants for this, for want of accommodation only seven students could be admitted to this course. In selecting students preference was given to officers of the Agricultural Departments in India. The course extended from the 2nd January, 1933, to the 15th February, 1933.

A dairy student from the Institute of Animal Husbandry Bangalore, was also given a short training in this Section.

SEASON AND RAINFALL

The most notable feature of the season was the incidence of a severe frost in January 1933, a phenomenon which had not occurred in Bihar for about 30 years. Delicate crops like tobacco and chillies were the worst affected, and were almost completely killed. These crops suffered more on dry light soils deficient in moisture than on clayey and moisture-retaining lands. Plots of tobacco and chillies that had been irrigated in the Botanical Section, for instance, escaped severe damage, while plots which were not so treated were affected seriously.

The total annual rainfall remained below the average for the last 25 years (1906—1930) by 8·71 inches. The rainfall in the *kharif* season was well distributed, but was 33 per cent. less than the average of 25 years ending 1930. The major portion of the shortage was in July and August, the middle period of the season. Consequently the *kharif* crops, specially rice and maize, suffered on account of deficiency of rain. For the sowings of *rabi* crops, however, the rainfall was quite sufficient in November, but was a little late for some crops like peas, *sarson*, etc.

Statement of rain in the Botanical Section in 1932-33

Month	Average for 25 years (1906—30)	From 1st June 1932 to 31st May 1933	Difference
	Inches	Inches	Inches
June 1932	7·53	7·01	—0·52
July	11·08	6·04	—5·04
August	14·09	7·12	—6·97
September	8·05	7·54	—0·51
October	1·81	0·60	—1·21
November	0·43	2·71	+2·28
December	0·18	0·30	+0·12
January 1933	0·34	0·03	—0·31
February	0·68	0·59	—0·09
March	0·41	0·00	—0·41
April	0·56	1·36	+0·80
May	1·44	4·59	+3·15
Total	46·60	37·89	—8·71

Statement showing the seed distribution in 1932-33 of improved crops evolved in the Botanical Section, Pusa

Crop	Variety	By the Botanical Section, Pusa	By the Pusa Farm	Total
		lb.	lb.	lb.
Bastard	Type 1	23	..	23
	„ 2	2	..	2
	„ 21	3,309	4,526	7,835
Chilli	„ 34	4 oz.	..	4 oz.
	„ 41	3 oz.	..	3 oz.
	„ 51	4 oz.	..	4 oz.
Gram	„ 2	50	..	50
	„ 6	1	..	1
	„ 17	469	1,414	1,883
	„ 25	230	443	673
	„ 28	63	..	63
	„ 58	258	716	974
	„ 51	217	..	217
Linseed	„ 12	1,168	638	1,806
	„ 121	652	346	998
	„ 124	279	329	608
	Hybrid 2	1	..	1
	„ 10	20	..	20
	„ 11	1	..	1
	„ 13	1	..	1
	„ 21	16	..	16
	„ 55	72	..	72
	„ 63	1	..	1
	„ 68	16	..	16
Lentil	Type 2	2	..	2
	„ 11	51	..	51

Crop	Variety	By the Botanical Garden, Pusa	By the Pusa Farm	Total
		lb.	lb.	lb.
	Type III-54 . . .	2	..	2
	„ III-86 . . .	101	535	636
Mung . . .	„ 23 . . .	1	..	1
	„ 28 . . .	2	..	2
	„ 34 . . .	2	..	2
	„ 36 . . .	1/2	..	1/2
	„ 53 . . .	1/2	..	1/2
Oats . . .	B. S. 1 . . .	880	4,155	5,035
	B. S. 2 . . .	337	1,008	1,345
	Hybrid A . . .	18	..	18
	„ B . . .	12	..	12
	„ C . . .	906	..	906
	„ D . . .	12	..	12
	„ E . . .	12	..	12
	„ F . . .	53	..	53
	„ G . . .	12	..	12
	„ H . . .	42	..	42
	„ I . . .	12	..	12
	„ J . . .	349	..	349
	„ K . . .	12	..	12
	K. S. 10 . . .	6	..	6
Patwa . . .	Type 3 . . .	50	..	50
	„ 6 . . .	94	..	94
	New Type . . .	88	..	88
Paddy . . .	Culture 66 (A) . . .	26	..	26
	„ 490 . . .	25	..	25
	„ 753 . . .	25	..	25
	„ 836 . . .	25	..	25
	„ 850 . . .	25	..	25

Crop	Variety	By the Botanical Section, Pusa	By the Pusa Farm	Total
		lb.	lb.	l ^b .
<i>Rahar</i>	Type 15	87	..	87
	„ 16	169	20	189
	„ 5	1	..	1
	„ 24	627	..	627
	„ 41	41	..	41
	„ 50	330	..	330
	„ 51	351	..	351
	„ 64	227	..	227
	„ 69	89	82	171
	„ 80	177	..	177
	„ 82	229	..	229
Safflower . . .	„ 30	16	..	16
Sesamum . . .	„ 7	27	..	27
	„ 29	101	..	101
Tobacco . . .	„ 28	15	..	15
	Hybrid 177	9	..	9
	Type 18	1/2	..	1/2
<i>Urid</i> . . .	„ 7	1/2	..	1/2
	„ 14	1	..	1
	„ 15	2	..	2
	„ 17	1/2	..	1/2
	„ 22	1/2	..	1/2
	„ 23	2	..	2
Wheat . . .	Pusa 4	264	2,206	2,470
	Pusa 12	956	1,603	2,559
	Pusa 52	755	7,859	8,614
	Pusa 80—5	968	206	1,174

Crop	Variety	By the Botanical Section, Pusa	By the Pusa Farm	Total
		lb.	lb.	lb.
	Pusa 101 . . .	1,765	..	1,765
	Pusa 111 . . .	832	503	1,335
	Pusa 112 . . .	4	..	4
	Pusa 114 . . .	101	..	101
	Pusa 115 . . .	82	..	82
	Pusa 120 . . .	10	..	10
	Pusa 165 . . .	10	..	10

II. INVESTIGATIONS

WHEAT (*Triticum vulgare* Host.)

The year under report was one of average yields and bushel weights compared favourably with the average of previous years. This may be seen from the following table :—

Wheat	Weight per bushel in lb.		
	Average of 6 years ending 1930-31	1931-32	1932-33
Pusa 4	63.50	66.1	66.3
„ 12	61.35	65.0	64.3
„ 52	63.94	66.8	66.4
„ 101 . . . . .	..	66.8	67.1
„ 111 . . . . .	..	66.2	66.1
„ 114 . . . . .	..	66.7	64.2

Frost damaged the early wheats, preventing the formation of grain in those varieties which were coming into ear at the time of the frost. This was well illustrated by the coefficient of correlation between length of ear and number of grains per ear in

the year under report. This biometrical constant has been calculated for the three chief Pusa wheats for the past eight years, and in the early wheat Pusa 4 in the past season a much lower value for the coefficient of correlation was realized than in the preceding years. The results are described in detail in a paper submitted for publication.

A regular system for maintaining the purity of the seed supply of the established Pusa wheats has been established in the Botanical Section. Seed is taken from typical single plants of each type every year and in the succeeding year is sown in five rows. Seed from the five rows is sown in a small plot in the next year and from this plot sufficient seed is obtained to sow one acre in the following year. From this, seed is given in the next season for sowing on ten-acre plots in the Agricultural Section on the Pusa Farm. The crop on the Farm is therefore only four generations removed from a single plant, and this seed is available for distribution to different departments of agriculture and others.

Outside India also Pusa wheats are gaining a reputation for yield and quality. Thus in Rhodesia (*Rhodesia Agr. Jour.*, Volume XXX, January 1933) a prize for the best bag of seed wheat was won with Pusa 4. The Director of Plant Breeding, New South Wales, reports—"We have had several Pusa wheats from time to time from India and of these Pusa 4 is now grown fairly extensively in New South Wales, being amongst the twenty leading varieties in this State. Pusa 12 appears to be resistant to flag smut and may be of a value as a parent in breeding. Pusa 111 has so far only been tested on a small scale but it is promising in comparison with Pusa 4. Pusa 113 is a promising wheat with good quality grain and so far it has been more productive than Pusa 4 in small tests. Pusa 114 may prove of value in our dry districts but is very susceptible to stem rust."

The wheat-breeding work with the hybrids between Federation and Pusa 4 and Federation and Pusa 52 has now reached the stage at which yield trials are being conducted with the more promising hybrids. Two trials were laid down in Latin Squares in the year under review—the incidence of frost has however seriously affected the significance of the results. One of the hybrids (No. 1054) has been tested in the U. S. A. and found resistant to five physiological forms of *Puccinia triticina*.

BARLEY (*Hordeum vulgare* L.)

The demand for the seed of Type 21 barley now far exceeds the supply, and the popularity of this type as a high yielding variety necessitates that larger areas of this be cropped in future. During the year under review only 3,300 lb. could be supplied

from the Botanical Section and 4,526 lb. from the Pusa Farm. The Deputy Director of Agriculture, Muzaffarpur, in addition, has been making large-scale distributions of this type.

At the Sepaya Agricultural Farm in North Bihar an average yield of 1,868 lb. per acre was obtained this year from an area of 8.5 acres, and in varietal trials conducted there Pusa Type 21 beat both Pusa Type 23 and local barley significantly by 9.6 per cent. and 31 per cent. respectively. The Gungowli Concern in North Bihar reports that this type of barley has averaged 35 maunds (2,870 lb.) per acre during this year. The Superintendent, Muzaffarnagar Farm, United Provinces, obtained the following yields in a trial conducted by him this year :—

Muzaffarnagar trial

Type	Average yields in lb. per acre
Pusa Type 21	3,290.5
Cawnpur barley	2,714.0
Local barley	2,863.0

Trials conducted during the year under the directions of Economic Botanist to Government, Cawnpur (In charge of barley and cotton investigations), gave the results shown below :—

Cawnpur trial

Raya Farm trial

Type	Average yields in lb. per acre	Type	Average yields in lb. per acre
Pusa Type 21	3,115.4	Pusa type 21	3,678.8
Cawnpur Type 251	2,489.0	Cawnpur type 251.	3,826.0
Cawnpur Type 255	2,737.0	Local barley	4,107.6

At the Government Farm, Etawah, a yield of 3,004.4 lb. has been obtained from Pusa barley Type 21 this year from an area of 0.80 acre, giving an average of 3,755.6 lb. per acre. The Farm Superintendent reports that this type is better than Cawnpur 255, that its stand was excellent, and that the type would be tried again next year.

A sample of Pusa barley Type 7, which has invariably proved to be a poor yielder under Pusa conditions but which possesses a xerophytic type of root-system adapted to the soils of dry tracts, was sent to Rawalpindi in the Punjab for trial against some of the Punjab barleys, to determine its suitability for that tract, but the report of the Manager of the Agricultural Station shows that there too this type has failed to do well.

The early maturing hulless types of barley appeared to be damaged by frost to a considerably greater extent than the hulled types. Differential response to frost effect was also shown by various F_2 families growing under identical conditions in one and the same field. Whereas families from crosses in which both the parents were hulled showed hardly any damage, most of the families which had a hulless barley (Pusa Type 24) as one of the parents exhibited deformity of the ear-head and an indifferent amount of seed setting as an effect of frost.

A number of barley crosses in F_2 and F_3 generations were studied during the year and some very desirable types appear to have been evolved and will receive further attention in the future.

The investigation regarding the resistance of all the 24 different types of Pusa barleys to *Helminthosporium* and the efficacy of certain seed disinfectants to control the disease has been continued with the collaboration of Dr. Mitra. Details of the results obtained will be found in the report of the Imperial Mycologist.

Some Pusa barleys have lately been used by the Geneticist of the Department of Agriculture, Victoria, Australia, who reports that the five Pusa types tried by him (viz., Pusa barley Types 7, 12, 20, 21 and 24) mature from 7 to 14 days in advance of Pryor, the standard Australian variety, and, on this account, are of definite value for breeding purposes. He also reports that of more than 100 importations from numerous countries, these Pusa types are the most promising for use as parent material. Types 12 and 20 have been mated with Pryor and Plumage Archer for the production of early malting varieties, and with Cape for early feed. In addition, Type 24 will be used by him for the production of an early feed type suited to the drier areas of the State. A number of F_1 , F_2 and F_4 cross-breds, the progeny of these matings, are undergoing field trials, and contain some very promising material. These reports of the success of Pusa barleys outside India are very encouraging.

OATS (*Avena sterilis* L.) .

A paper on the improvement of the oat crop by selection and the acclimatization of exotic types has been sent in for publication. This paper embodies details regarding the isolation and cultivation of B. S. 1 and B. S. 2 oats and also gives an account of the attempted acclimatization of a number of exotic oats at Pusa. Invariably all European and American types of oats yield a profuse quantity of fine straw but they are all much too late to set a normal amount of seed under Indian conditions.

The inheritance of some characters in crosses between Scotch Potato and Pusa oats as well as between Abundance and a Pusa type formed the subject of a second paper sent in for publication. Both the Scotch Potato and the Abundance oats belong to the species *A. sativa* L. and all the Pusa oats belong to the species *A. sterilis* L. variety *culta*, but no difficulty was experienced in obtaining fertile hybrids from these inter-specific crosses. A number of very promising hybrids have been fixed from this material. It may be noted that single factor differences have been observed between *sativa* and *sterilis* types of base, *strong* and *weak* awns, and *long* and *short* basal hairs.

Two factors appear to be responsible on the other hand for the inheritance of amount of basal hairs, hairs on the margin of leaves.

Transgressive segregation indicating the presence of multiple factors has been observed in the inheritance of height of plants in all the three crosses studied, number of days taken to head out, and the number of spikelets per panicle in Crosses I and II (Scotch Potato \times B. S. 4 and Scotch Potato \times B. S. 2). While in Cross III (Abundance \times B. S. 4) dominance of early maturing plants and of plants with a low spikelet number has been observed.

Yield trials with twelve hybrids and B. S. 1 and B. S. 2 oats, as outlined in the last year's annual report, were again conducted both at Pusa and at Karnal and have yielded promising and interesting results. They will be repeated for the third time in the ensuing season before any definite conclusions can be drawn. The response of different types to variations in soil and climate will, it is hoped, be elucidated by these trials.

The Assistant Director of Agriculture, Sepaya, conducted a varietal trial this year with two Pusa oats B. S. 1 and Hybrid C and found that under his conditions the former was significantly superior to the latter by about 30 per cent. in yield of grain. The yield of B. S. 1 in this experiment came to an average of 34.8 maunds (2,854 lb.) per acre.

A comparison of B. S. 1 and Pusa Hybrids C, F, and J against local farm oats was made this year at the Raya Agricultural Farm by the United Provinces Department of Agriculture and the following result has been reported :—

Name of variety	Area sown in acres	Actual outturn of green fodder in lb.	Outturn per acre of green fodder in lb.
Hybrid C	0.2	6,892	34,460
Hybrid F	0.2	4,276	21,380
Hybrid J	0.2	6,068	30,340
B. S. 1	0.2	5,535	27,675
Farm Seed (Raya)	0.2	5,705	28,525

Hybrid C has been reported to yield the maximum quantity of green fodder but is rather early in maturity for Raya conditions.

PADDY (*Oryza sativa* L.)

The isolation of 135 types of Bihar paddies is practically completed, but their study during the year under review was hindered by the lack of rain and its bad distribution. The work will be completed during the current year.

GRAM (*Cicer arietinum* L.)

The results of the cross between a Kabuli (Pusa Type 2) and a *desi* (Pusa Type 18) gram are now complete and have been written up for publication. The characters studied include flower colour, seed shape and seed colour. A scheme of factorial analysis for these characters and a genetical explanation of their inheritance has been devised.

Yield trials between some of the new types (48, 49, 51, and 58) and the old established Type 17 were carried out both at Pusa and at Karnal. In both cases Type 58 proved decisively superior to all the other types including Type 17. These two results, in combination with last year's result, suggest that in Type 58 we have definitely obtained a gram superior in yielding power to the older established varieties. Trials with Type 58 will be continued at Pusa and at Karnal next year and are also being organized in collaboration with provincial departments of agriculture in Sind, Punjab and United Provinces.

In a second yield trial at Pusa with Types 53, 54, 55 and 67, against Type 17 the former were all superior to Type 17. Further repetitions of this trial will be necessary to place the results on a significant basis.

PIGEON-PEA (*Cajanus indicus* Spreng).

This crop suffered badly from frost almost everywhere except in the Botanical Section where the conservation of soil moisture appears to have been sufficient to enable the crop to withstand the frost to a considerable degree.

A yield trial with a number of the most promising types was carried out and four types, *viz.*, Types 15, 24, 51 and 64, all proved significantly better than local seed. Type 51 is erect in habit and

possesses a large yellow-brown seed, and is also wilt-resistant. These characters together with its high yielding capacity should make this type of great economic importance. At the Government Farm, Etawah, United Provinces, this type was grown on 1.50 acres of land this year and gave an average outturn of 2,228.5 lb. per acre. The Farm Superintendent reports that it was very little affected by frost in the month of January, while local *arhar* in adjoining cultivators' fields was badly affected.

Work on the inheritance of wilt-resistance was continued during the year under review.

A large F_2 population from the cross Type 80 (resistant) \times Type 5 (susceptible) and its reciprocal was grown in two fields which were artificially infected with the disease, and also in a field which was not infected. The inheritance of flower colour was studied in relation to the disease and it was found that segregation was on a 9 : 3 : 3 : 1 ratio and that the ratio was not significantly disturbed in the population in the infected fields by the incidence of the disease. This means that the property of resistance to wilt disease is inherited independently of colour in the flower. The other characters studied, seed colour, stature and habit, all exhibited the same independence of disease-resistance, and we conclude therefore that the factors for disease-resistance are not linked with the factors which are concerned with the inheritance of any of these characters. This confirms the conclusions drawn from a previous experiment when an F_2 population was grown in an infected field.

The cross was first made some five years ago and the work during the past season was done to confirm the previous results. From the original cross the succeeding hybrid generations have been grown every year both under infected and non-infected conditions. In 1931-32 when the cross was in the F_4 generation it was noticed that some morphologically identical phenotypes were growing both in the population which together with all the preceding generations had been reared in non-infected fields and in the population of which all preceding generations had been grown under artificially infected conditions. The latter possessed a considerable degree of resistance to wilt, otherwise they would never have survived. Five phenotypes were selected from among these resistant hybrids in F_4 and five morphologically similar phenotypes were selected from among the hybrids (also in F_4) which had been reared under non-infected conditions. All the ten cultures were grown in an infected field in the year under review and it was found that four of the five hybrids reared under selection by the disease were strongly resistant, whereas the same phenotypes which had been reared out of contact with the disease proved heavily susceptible. This shows that the same morphological phenotype may be either resistant or susceptible.

A test for wilt-resistance of five types, with seven replications against Type 5, the control, gave the following results:—

Type	Average percentage of deaths
5	84.93
16	6.12
41	0.72
51	8.88
80	0.82
82	1.07

The difference in wilt-resistance between Type 5 and the other types is statistically significant below the one per cent. level.

PEAS (*Pisum sativum* L. and *P. arvense* L.)

The study of the types was continued and a yield trial with five types, grown without support, was carried out.

LENTILS (*Ervum lens* L.)

A preliminary varietal trial with eight hybrid types of lentils against two selections was run this year, and it was found that some of the hybrid types out-yielded the selections and showed great promise. Regular yield trials with these will be taken up during the next season.

The study of inheritance of some characters in this crop has been completed and the results will be written up for publication.

URID AND MUNG (*Phaseolus Mungo* L. and *P. radiatus* L.)

Two definite types of root-systems, viz., mesophytic and xerophytic systems, were found in the Pusa types of green and black grams. Types coming from the alluvial soils of Bengal and Bihar invariably had mesophytic roots, whereas types which originated from seed collected from drier localities of the United Provinces, Punjab, North-West Frontier Province, and Peninsular India as well as most of the types from Burma all possessed a xerophytic type of root-system. The maximum depth of the main tap root was greater in the xerophytic than in the mesophytic types of both *mung* and *urid*, but *urid* generally had a distinctly deeper root penetration than *mung*. All early maturing types had a shallow working depth of their roots while all late maturing types had a deeper working depth. The lateral spread of secondary

roots was observed to be much greater in the mesophytic than in the xerophytic types of root-systems. A paper on the subject was submitted during the year under review.

SANK-HEMP (*Crotalaria juncea* L.)

Owing to the failure of seed setting in this crop a large number of promising cultures from original samples received from different parts of India had to be rejected. Selections have been made and will be continued for some time in order to evolve one or more good types by mass selection.

INDIAN HEMP (*Cannabis sativa* L.)

This is a dioecious crop in which natural cross fertilization and wind pollination is the common rule. In the preparation of the narcotic, *ganja*, all the male plants are invariably weeded out before any pollination can take place. This is an important consideration in maintaining the purity of a type which may be evolved by mass selection. A number of selections have therefore been made from the *ganja* usually cultivated in Bihar which appears to be a mixture of very variable types. It is proposed therefore to continue the work on the selection and fixing of a good type of *ganja*.

The following sex ratios were observed this year in the different types of hemp studied :—

	Number of		Ratio of	
	♂ Plants	♀ Plants	♂ Plants	♀ Plants
Pusa H-17	16 :	20	1 :	1.25
Pusa Type 1	170 :	378	1 :	2.22
Pusa Type 2	102 :	215	1 :	2.11
B. and O. type (sample obtained from Hurlingham)	174 :	288	1 :	1.65

It is evident, of course, that the higher the proportion of female plants present in this crop, the higher is the yield of the final product (*ganja*) obtained and the less the amount of labour which has to be expended in weeding out male plants.

TOBACCO (*Nicotiana tabacum* L.)

Work was continued on the inheritance of characters in a cross between white and pink flowered types. The progress of investigation in curing and yield in the crop was seriously hampered by the damage due to frost.

CHILLIES (*Capsicum annum* L. and *C. frutescens* L.)

The original types were maintained and the work of isolating unit species in Goa chillies was continued. The results of the study of the inheritance of characters were published and the cross (Type 3 \times Type 29) is regularly maintained in the Section for instructional purposes. New crosses to elucidate the inheritance of anther colour were made.

HEMP (*Hibiscus cannabinus* L. and *H. Sabdariffa* L.)

The study of the inheritance of characters in the crosses with *H. sabdariffa* var. *altissima* was continued and the results of the F_2 generation confirmed the conclusions drawn from the F_2 generation in the previous season.

An investigation on the variability of a Mendelian ratio in relation to the life-cycle of the parent was commenced with these crosses as they are well adapted to this study.

LINSEED (*Linum usitatissimum* L.)

Testing of the ninety hybrids obtained from crosses, the results of which have already been published, was continued. Two hybrids, H. 55 and H. 21, were found to be equal to the standard Type 12 in yielding power and to possess considerably higher oil percentage. Both these hybrids have the "white" seed colour which is more popular with the trade than the dark. Further tests with these and other hybrids will be continued.

Some types of linseed from Australia were grown, and it is possible that a use may be found for them as parents in crosses with Indian linseed. The Australian types possess large flowers but their oil content in the past season was low. Further work on these types is needed; at present they appear to be mostly too late in maturity for Indian conditions.

The crosses with Type 15 described in the last annual report were continued to the F_2 generation and the theory of the inheritance of petal colour, which was previously described, was confirmed.

The F_2 generations of the crosses Type 15 \times Type 4, Type 15 \times Type 21, and Type 15 \times Type 24, were grown and studied. The F_2 results of segregations for petal colour in the first on tri-hybrid, in the second on monohybrid and in the last on dihybrid ratios were confirmed.

The F_2 generations of the following crosses were also grown and studied—Type 15 \times Type 12, Type 15 \times Type 20, Type 15 \times Type 22, Type 1 \times Type 24, and Type 4 \times Type 24. In the cross Type 15 \times Type 12, the segregation for petal colour character was on a 9:3:3:1 ratio. The cross Type 15 \times Type 20 gave an indication of a dihybrid segregation for petal colour but due to difficulties in diagnosing different phenotypes decision as to the precise nature of the segregations in this cross must remain in abeyance. The results of Type 15 \times Type 22 were similar to those of Type 15 \times Type 21 studied last year where in F_1 the white petal was apparently dominant to blue and in F_2 a ratio of 3 whites: 1 blue was obtained. In the crosses Type 1 \times Type 24 and Type 4 \times Type 24 a ratio of 9 blue like F_1 : 3 blue like Type 24 parent: 4 white like the other parent was obtained for petal colour.

The results of these crosses have thrown light on the genetic constitution of most of the types and particularly of Type 15 which has hitherto been obscure.

The mean oil-content of 112 varieties and the maximum in any variety were respectively 39.03 and 42.78 per cent. Thus there is a decrease of 3.72 per cent. in the former and of 4.64 per cent. in the latter compared with the last year's (1931-32) figures. The minimum oil-content, however, shows an increase of 0.17 per cent. over last year's figures.

Statement showing the oil percentage of some high yielding linseed hybrids and the standard types from 1928-29 to 1932-33 (5 years)

Variety	Oil percentage					
	1928-29	1929-30	1930-31	1931-32	1932-33	Mean
Type 12 . . .	36.67	36.93	37.68	37.29	37.74	37.26
Type 121 . . .	40.01	40.13	38.88	41.50	39.80	40.06
Type 124 . . .	38.22	39.86	37.44	42.30	39.07	39.38
Hybrid 10 (T. 12 \times T. 1)	43.00	42.20	41.49	45.50	41.90	42.82
Hybrid 21 (T. 12 \times T. 8)	41.80	39.74	37.66	42.20	38.88	40.05
Hybrid 55 (T. 8 \times T. 121)	44.03	40.26	42.23	44.73	42.78	42.81
Hybrid 68 (T. 22 \times T. 121)	43.16	40.50	40.91	43.94	39.58	41.62

SAFFLOWER (*Carthamus tinctorius* L.)

The thirty-four types were maintained. The seeds of the variegated segregates from the variegated plant in Type 27 observed for the first time in 1929-30 which segregated into normal and variegated plants in the following year having failed to germinate last year the original stock of Type 27 seed was grown. A number of variegated plants were again observed out of which about a dozen were selfed for further study.

A few types have been crossed *inter se* with a view to study inheritance in this crop. The percentage of success was small but it shows that the types are crossable. Because of the thorny nature of plants and the aggregation of small, delicate flowers in a compact head the operations of emasculation and pollination were rendered very difficult.

SESAMUM (*Sesamum indicum* D. C.)

Preliminary tests indicate that Types 3, 7 and 29 will be good yielders. The study of the inheritance of characters in this crop was continued. The economic object of this work is the production of a heavy-yielding white-seeded hybrid. White seed is a desirable character in this crop as such types yield a lighter coloured oil.

BRASSICA

The tentative classification of the types in the three self-fertile species, viz., (1) Yellow *sarson* (*B. campestris* var. *sarson* Prain); (2) *Rai* (*B. juncea* Hooker); (3) Chinese mustard (*B. rugosa* var. *cuneifolia*, Prain) was checked and revised. Herbarium specimens of all the self-fertile and self-sterile groups of Brassica were prepared and sent to the Royal Botanic Gardens, Kew (England), for identification and confirmation of our classification of these groups.

The F₁ generations of the crosses between yellow *sarson*, a self-fertile group, and black *sarson* and Burma *sarson* belonging to the self-sterile groups were studied at Pusa to elucidate the inheritance of self-fertility and of seed characters. These crosses were :—

- (1) Yellow *sarson* × Black *sarson* late (*B. campestris* var. *oleifera* Prain) and its reciprocal.
- (2) Yellow *sarson* × Burma *sarson* (*B. oleracea* var. *chinensis* Prain) and its reciprocal.

Similar crosses between yellow *sarson* and *toria* (*B. napus* L. var. *dichotoma* Prain); and between yellow *sarson* and black *sarson* early (*B. campestris* sub-sp. *napus* var. *dichotoma* Duthie and

Fuller) were studied at the Botanical Sub-station, Karnal. The consideration of the mode of inheritance is made difficult by the fact that the self-sterile groups cannot be pure for the different characters. Some definite idea about the scheme of inheritance will be got next year from the study of the F_2 generations of the crosses. At present it appears that self-fertility is dominant over self sterility, and that red seed colour of *toria* or *sarson* is dominant over yellow seed colour of the yellow *sarson*.

The study of these crosses further shows that it is possible to secure a self-fertile plant with red seed, thus explaining the nature of the natural crosses that were found to be self-fertile and having red seed. It is therefore now possible to produce a desirable high yielding strain of red-seeded, self-fertile *sarson* or *toria*.

The *inter se* crosses between turnip and other Brassica group that were made at Pusa last year were studied at the Botanical Sub-station, Karnal, in their F_1 generation, and the results are stated in the report of that station.

Preliminary observations were made as regards the influence of cloudy weather on seed-setting and these will be repeated next year before any conclusion is drawn. Some strains of the self-sterile groups were grown at isolated places in order to make them pure multiple strains.

TARAMIRA (*Eruca sativa* L.)

The sterility experiment was continued and some results will be available next year.

STATEMENT SHOWING THE YIELD OF CROPS IN THE BOTANICAL SECTION IN 1932-33

Crop	Plot	Outturn of grain in lb.			Remarks
		Area in acres	Actual	Per acre	
Wheat—					
Pusa 4 .	Western Orchard border D.	0.09	137	1,522	
„ 4 .	Orchard 4A part .	1.00	1,013	1,013	
„ 12 .	Pentagonal field part	1.05	1,826	1,739	
„ 52 .	Orchard 4A part .	1.03	1,205	1,170	
„ 80—5	Pentagonal field part	1.06	1,886	1,806	

STATEMENT SHOWING THE YIELD OF CROPS IN THE POTENTIAL SECTION IN 1932-33—contd.

Crop	Plot	Area in acres	Outturn of grain in lb.		Remarks
			Actual	Per acre	
<i>Wheat—</i> contd.					
Pusa 80—5	Pentagonal west border.	0.13	180	1,385	
„ 101	„ field part	1.06	1,952	1,842	
„ 111	„ „ „	1.05	1,328	1,265	
„ 111	„ east border	0.11	170	1,545	
„ 4	N. T. G. 1 part	0.06	148	2,466	
„ 12	N. T. G. 1 part	0.06	139	2,317	
„ 52	N. T. G. 1 part	0.06	139	2,317	
„ 80—5	N. T. G. 1 part	0.06	133	2,217	
„ 101	N. T. G. 1 part	0.06	162	2,700	
„ 111	N. T. G. 1 part	0.06	125	2,083	
„ 114	N. T. G. 1 part	0.06	119	1,983	
Hybrid A	Orchard 6A part	0.036	45	1,250	
„ B	„	0.036	37	1,028	
„ D	„	0.036	49	1,361	
„ E	„	0.036	44	1,222	
„ F	„	0.036	41	1,139	
„ G	„	0.036	36	1,000	
Pusa 52	„	0.036	67	1,861	
„ 4	„	0.036	42	1,167	
Hybrid K	„	0.036	45	1,250	
„ L	„	0.036	45	1,250	
„ M	„	0.036	27	750	
„ R	„	0.036	47	1,306	
„ N	„	0.036	45	1,250	
„ J	„	0.036	58	1,611	
„ O	„	0.036	26	722	

STATEMENT SHOWING THE YIELD OF CROPS IN THE BOTANICAL
SECTION IN 1932-33—*contd.*

Crop	Plot	Area in acres	Outturn of grain in lb.		Remarks	
			Actual	Per acre		
<i>Wheat—</i>						
conold.						
Pusa 52 .	Orchard 6A part .	0.036	56	1,556	} The crop was badly damaged by frost.	
„ 52 .	Orchard 1A part .	0.153	208	1,359		
Local .	„ .	0.153	196	1,281		
<i>Sesamum—</i>						
Type 1 .	N. T. G. 10 part .	0.14	54	386		
„ 7 .	„ .	0.07	31	443		
„ 9 .	„ .	0.07	19	271		
„ 15 .	„ .	0.035	11	314		
„ 23 .	„ .	0.035	9	257		
„ 28 .	„ .	0.07	29	414		
„ 29 .	„ .	0.14	73	521		
<i>Tobacco—</i>						
Type 63 .	Orchard 3A and B part.	0.54	471	872 Leaf	} The crop was badly damaged by frost.	
„ 58 .	„ „ .	0.55	348	633 „		
Hybrid 142	Inside Musahar .	1.60	1,152	720 „		
„ 177	„ .	0.40	236	590 „		
Cash .	„ .	0.60	416	693 „		
<i>Gram—</i>						
Type 17 .	Riverside east, east- ern half.	0.38	510.4	1,343.2		
„ 25 .	N. T. G. 4 . .	0.33	469.4	1,422.4		
„ 28 .	Barah 1 part .	0.10	120.9	1,209.0		
„ 41 .	„ .	0.02	41.0	2,050.0		
„ 58 .	Riverside east, west- ern half.	0.38	701.1	1,845.0		
„ 17 .	Barah 1 . .	0.073	163.3	2,237.0		
„ 48 .	„ . .	0.073	170.4	2,334.2		
„ 49 .	„ . .	0.073	157.0	2,150.7		

STATEMENT SHOWING THE YIELD OF CROPS IN THE BOTANICAL
SECTION IN 1932-33—*contd.*

Crop	Plot	Area in acres	Outturn of grain in lb.		Remarks
			Actual	Per acre	
<i>Gram—</i> contd. Type 51 .	Barah 1	0.073	187.2	2,564.4	
„ 58 .	„	0.073	203.0	2,780.8	
„ 17 .	„	0.073	140.1	1,919.2	
„ 53 .	„	0.073	183.75	2,517.1	
„ 54 .	„	0.073	176.6	2,419.2	
„ 55 .	„	0.073	156.4	2,142.5	
„ 67 .	„	0.073	177.9	2,438.1	
<i>Rahar—</i> Type 15 .	Orchard 4B	0.109	235.8	2,163.3	
„ 16 .	„	0.109	161.5	1,481.7	
„ 24 .	„	0.109	210.25	1,928.9	
„ 41 .	„	0.109	158.9	1,457.8	
„ 51 .	„	0.109	218.9	2,008.1	
„ 64 .	„	0.109	207.4	1,903.0	
„ 69 .	„	0.109	192.6	1,767.0	
„ 80A2	„	0.109	163.2	1,497.2	
„ 80A4	„	0.109	166.25	1,525.2	
„ 82 .	„	0.109	185.7	1,703.7	
Local .	„	0.109	188.4	1,728.6	
Type 24 .	Lawn plot 3	0.34	660.0	1,941.2	
„ 50 .	S. T. G. 6	0.20	403.8	2,019.0	
„ 51 .	S. T. G. 9	0.24	555.6	2,315.0	
<i>Pear—</i> A. 14 .	N. T. G. 9 part . .	0.06	30.75	512.5	Damaged more than other types by frost.
S. 14-1 .	„	0.16	104.5	653.1	Damaged to some extent by rats.

STATEMENT SHOWING THE YIELD OF CROPS IN THE BOTANICAL
SECTION IN 1932-33—*contd.*

Crop	Plot	Area in acres	Outturn of grain in lb.		Remarks
			Actual	Per acre	
<i>Peas—contd.</i>					
S. 35 .	N.T.G. 0 part. .	0.05	66.6	1,332.0	
S. 36 .	"	0.05	53.3	1,066.0	
S. 14-1 .	N. T. G. 2 . .	0.036	45.4	1,261.1	
S. 35 .	"	0.036	34.4	955.6	
S. 36 .	"	0.036	35.7	991.7	
A. 14 .	"	0.036	10.75	298.6	
Farm No. 1	"	0.036	33.3	925.0	
<i>Barley—</i>					
Type 21 .	W. River bank .	0.74	2,683	3,626	Poor and hetero- geneous plot. Barley put in after removal of fruit orchard. Sown very late after harvesting wrid. Ditto.
" 21 .	Orchard 2D . .	0.71	1,254	1,766	
" 21 .	Orchard 5A part .	0.40	486	1,217	
Local .	"	0.22	244	1,109	
<i>Oats—</i>					
B. S. 1 .	S. Barah border .	0.35	820	2,343	After taking a cutting of green leaves for fodder. Ditto.
B. S. 1 .	Outside Musahar 4	0.20	490	2,450	
B. S. 2 .	" " 2	0.20	363	1,815	
Hybrid F	" " 3	0.20	316	1,580	
" C .	" " 1A	0.50	1,189	2,378	
" J .	" " .	0.50	1,090	2,180	
" J .	N. T. G 5 part .	0.10	197	1,970	
" A .	"	0.05	74.50	1,490	
" B .	"	0.05	64.75	1,295	
" C .	"	0.05	130.0	2,600	

STATEMENT SHOWING THE YIELD OF CROPS IN THE BOTANICAL SECTION IN 1932-33--*contd.*

Crop	Plot	Area in acres	Outturn of grain in lb.		Remarks
			Actual	Per acre	
<i>Oats—contd.</i>					
Hybrid D.	N. T. G. 5 part	0.05	99.25	1,985	
" E	"	0.05	101.75	2,035	
" F	"	0.05	119.75	2,395	
" H	"	0.05	74.50	1,490	
" I	"	0.05	118.25	2,365	
" J	"	0.05	124.50	2,490	
" K	"	0.05	81.75	1,635	
B. S. 1	"	0.05	115.25	2,305	
B. S. 2	"	0.05	126.0	2,520	
<i>Lentil—</i>					
Type 11	S. T. G. 8 part	0.15	148	987	
Hybrid III-86.	"	0.15	141	940	
Type 11	S. T. G. 3 part	0.01	10.00	1,000	
" 47	"	0.01	19.25	1,925	
Hybrid A	"	0.01	21.75	2,175	
" B	"	0.01	20.50	2,050	
" C	"	0.01	18.75	1,875	
" D	"	0.01	16.25	1,625	
" E	"	0.01	16.50	1,650	
" F	"	0.01	19.25	1,925	
" G	"	0.01	18.00	1,800	
" H	"	0.01	18.75	1,875	
<i>Soyabean—</i>					
Type 12	Orchard 6B	0.1	154	1,540	
Hybrid 10	"	0.1	144	1,460	
" 13	"	0.1	129	1,290	

STATEMENT SHOWING THE YIELD OF CROPS IN THE BOTANICAL SECTION IN 1932-33—*concl'd.*

Crop	Plot	Area in acres	Outturn of grain in lb.		Remarks
			Actual	Per acre	
<i>Linseed—</i> contd.					
Hybrid 21	Orchard 6B	0.1	149	1,490	
„ 23	„	0.1	119	1,190	
„ 38	„	0.1	131	1,310	
„ 55	„	0.1	151	1,510	
„ 68	„	0.1	137	1,370	
<i>Safflower—</i>					
Type 30	S. T. G. 7	0.05	43	860	
<i>Hibiscus—</i>					
Type 3	Musahar Out No. 1.	0.30	69	290	
„ 3	South Orchard border.	0.09	24	266	
„ 6	Musahar Out No. 5.	0.28	120	428.5	
<i>Chillies—</i>					
(Semi dry)	Barah 3	0.85	438	515.33	Crop badly damaged by frost.

III. PUBLICATIONS AND PROGRAMME OF WORK FOR 1933-34

PUBLICATIONS

✓ *Deshpande, R. B.*—Studies in Indian Chillies No. 3. The inheritance of some characters in *Capsicum annum* L. *Indian Jour. Agri. Sci.* 3, 1933, 219-300.

✓ *Bose, R. D.*—Application of modern statistical methods to field trials. *Agri. and Livestock in India*, 1933.

..... and *Joglekar, R. O.*—Studies in Indian Pulses No. 6. The root-systems of green and black grams. *Indian Jour. Agri. Sci.* 1933.

Shaw, F. J. F. and Bose, R. D.—Studies in Indian Oats I. The improvement of the crop by selection and the acclimatization of exotic types. *Indian Jour. Agri. Sci.* 1933.

.....—Studies in Indian Oats II. Inheritance of some characters in interspecific crosses between *Avena sativa* L. and *A. sterilis* L. var. *culta*. *Indian Jour. Agri. Sci.* 1933.

✓ Shaw, F. J. F.—Wheat and Barley in India (written for the World's Grain Exhibition and Conference, Canada, 1933).

PROGRAMME OF WORK FOR 1933-34.

Investigations will be continued on the genetics of those crops which have formed the subject of this report. Special attention will be given to yield trials and statistical methods. Training of students will continue as in past years.

(2) Botanical Sub-Station, Karnal*(Financed by the Imperial Council of Agricultural Research)***I. INTRODUCTION**

Khan Saheb Abdur Rahman Khan held charge of the Station throughout the year.

The post of Farm Assistant was filled up by the appointment of Mr. R. B. Ekbote (L. Ag. Honours) who joined his duties at Karnal on the 20th February 1933.

TRAINING

All the post-graduate students of the Botanical Section, Pusa, visited the station in February 1933 and studied the following experiments :—

(1) Trials of two new hybrid wheats 120 and 165, which were too late for Pusa.

(2) Trials of Pusa barleys, wheats, etc., under irrigation. The reaction of the barleys and some varieties of wheat to rust under irrigated conditions was most striking.

(3) Yield trials of oats under irrigation.

(4) Yield trials of gram.

(5) Brassica types and cultures.

(6) F_2 and F_3 populations of gram crosses.

SEASON AND RAINFALL

The year 1932-33 was on the whole satisfactory. The out-turn of gram was exceptionally very high. Yields of wheat varieties were also a little better than those of last year.

Rainfall during 1932-33

Month	Inches
June, 1932	1.02
July	8.72
August	6.53
September	10.30
October	0.02
November . . . . .	..
December	2.06
January, 1933	0.09
February	1.02
March.	0.90
April	0.61
May	1.92
Total	33.19

MACHINERY

The 'Bulldog Lanz' crude oil tractor continued to work satisfactorily both in running the 'Consul' thresher and cultivating the land. The plough 'Consul (3B)' did not prove very suitable for irrigated stiff lands of the station. It makes land very uneven which is not desirable for irrigated lands. The 'S-ft. Baron' disc-harrow proved to be very useful both for cultivating the land before sowing and covering the seed when sown broadcast. The 'Consul' thresher did very good work in threshing wheat, barley and oats. This year it was adjusted so that the percentage of broken grains in wheat was negligible, i.e., less than 1 per cent. Grams can also be threshed in this machine but the percentage of broken grains comes to at the least 6 per cent.

II. INVESTIGATIONS

PADDY

Out of the 76 samples collected from different places in the Punjab and other parts of India, 125 different types have been isolated. Among these 10 types are very promising and are being grown on large observation plots for comparison. A tentative classification of all the isolated types has been made which will shortly be sent for publication.

WHEAT

One of the objects of starting the Karnal Sub Station was to provide an area in which late maturing varieties bred at Pusa might be tried under conditions which are more favourable for their development than are available in Bihar. A good deal of work has been done in this direction and two new hybrid wheats, 20-1 and 3-1, have given very good results at Karnal. Having proved successful in the preliminary tests permanent numbers P. 120 and P. 165 respectively have been given to them. Tests will be made simultaneously at Pusa at Karnal and at several farms in the Punjab and the United Provinces under various climatic and other conditions including canal irrigated, well irrigated and *barani* (rain-fed) lands.

The varieties to be tried at Karnal will be as follows:—P. 120, P. 165, P. 4, P. 12, Punjab 8A, and two other varieties selected by the Punjab Agricultural Department.

Two crosses of wheat were made in 1930 at Pusa and were taken to Karnal for study. The F_2 generation of these crosses was studied during the current year.

(1) P. 52 \times P. 111.

P. 111 \times P. 52.

(2) P. 111 \times 6-1-4-1 (P. 52 \times Fed.)

6-1-4-1 (P. 52 \times Fed.) \times P. 111.

The parents P. 52 and 6-1-4-1 (P. 52 \times Fed.), are fully bearded, while P. 111 is beardless. The F_1 plants of all the crosses were short-tipped. In F_2 the following segregation took place.

Name of the cross	Beard- less	Short tip- ped	Long tip- ped	Very long tip- ped	Half beard- ed	Fully beard- ed	Total
1. P. 52 \times P. 111 . . .	62	376	155	112	41	37	783
P. 111 \times P. 52. . . .	47	343	162	135	36	73	796
Total	109	719	317	247	77	110	1,579
2. 6-1-4-1 (P. 52 \times Fed.) \times P. 111	41	384	143	121	42	56	787
P. 111 \times 6-1-4-1 (P. 52 \times Fed.)	49	487	231	130	59	62	988
Total	90	871	374	251	101	118	1,775

It will be seen that the fully bearded and beardless classes are each 1/13th of the total population indicating a two factor segregation.

Cross No. 1	Beardless	Fully bearded	Total population
Observed	109	110	1,579
Expected	98.7	98.7	
Cross No. 2			
Observed	90	118	1,775
Expected	110.9	110.9	

All promising fully bearded plants have been selected for growing next year and it is hoped to obtain a bearded variety with the grain qualities of P. 111.

Many unfixed hybrid cultures of wheat originally sent from Pusa were grown and selection work was continued. The following five cultures of Canadian wheats were also grown :—

- (1) Garnet Ottawa beardless.
- (2) „ „ half bearded.
- (3) „ „ tipped.
- (4) Reward Ottawa short-tipped.
- (5) „ „ long-tipped.

All were late in maturity and produced shrivelled grains. They are more susceptible to black rust and are not suitable for growing in the Punjab. However they possess very good standing power and can be used as parents in crosses.

Some Japanese wheats were also tried but were badly attacked by black rust and gave very poor results.

The incidence of bunt (*Tilletia indica*) in wheat was severe in the year under report and was investigated by the Assistant Mycologist, Pusa. The disease was most severe in P. 112 and P. 113, was less severe in P. 111, P. 80-5 and P. 120 and was least in P.'s 4, 12, 52, 114 and 165. All seed will be treated before next sowing.

A statement showing the outturn of different types of wheat grown on a large scale is appended.

GRAM.

All the 84 types of gram were maintained.

A yield trial experiment in randomized blocks was carried out with the following four varieties with 10 replications :—T. 58, T. 17, T. 28, Local. Type 58 gave the best results with a yield of 3,021 lb. per acre, local was second with a yield of 2,702 lb. per acre but its grain colour is not popular. T. 17 was third with a yield of 2,507 lb. per acre and T. 28 the last, its yield being 1,949 lb. The results were tested statistically by the analysis of variance and it was shown that the superiority of T. 58 was statistically significant at the one per cent. level. This result agrees with the results of two other yield trials conducted at Pusa in 1931-32 and 1932-33 and we may regard the establishment of T. 58 as a very high yielder as practically proved. The results will be published in detail after experiments at Pusa and at Karnal during the next (1933-34) season.

Sixteen promising types were grown on large observation plots to ascertain which of them are suitable for a yield test. The results are shown in statement No. II appended in the end. Types 46 and 67 seem to be the best in yield and quality and will be grown next year on a large scale to get sufficient seed for future yield trials. T. 28 is the best of the small white seeded types and has kept up its position.

Grain crosses. The following crosses were studied in the year under report :—

F_2 generations of

- (1) T. 9 \times T. 13
- (2) T. 12 \times T. 11
- (3) T. 82 \times T. 1

F_2 generations of

- (1) T. 39 \times T. 2
- (2) T. 2 \times T. 39
- (3) T. 52 \times T. 11
- (4) T. 21 \times T. 11
- (5) T. 82 \times T. 1
- (6) T. 1 \times T. 82

The inheritance of colour in flower has been studied fully and the results are being published.

So far three factors for colour in the petal have been identified. These factors are, a factor B for blue colour, a factor P which modifies blue to pink and a factor W which inhibits the development of green colour on the edge of the standard. The factor P by itself in the absence of B has no effect on the colour of the flower and white flowers therefore may be of several different genotypes. The development of greenness on the edge of the standard is controlled by the presence of W and is independent of the other colour factors P and B.

The inheritance of seed characters such as colour, shape, surface, etc., is being studied and will form the subject of a later paper.

OATS

Last year a yield trial of some Pusa oats was laid out in randomized blocks. Thirteen varieties were replicated five times in blocks of 1,000 square feet each. The trial was repeated also in the year under report and the results are given below :—

Average yield in lb. per acre

Hybrid	Yield in lb.	Rank
A	1,594.3	10
B	1,136.1	13
C	2,077.8	5
D	1,994.9	7
E	1,899.2	6
F	1,633.5	9
G	2,186.7	4
H	1,568.1	11
I	1,542.0	12
J	2,339.3	3
K	1,677.1	8
B. S. 1	2,432.0	2
B. S. 2	2,504.7	1
General mean	1,890.05	
Standard error of mean difference	118.01	

BARLEY

Last year the best types of Pusa barleys were attacked by rust very badly. This year all the 24 types were grown on small scale to ascertain their susceptibility to rust at Karnal under irrigated conditions. No type proved to be immune, but some are more resistant to rust than others. Types 12, 17, 21 and 23 seem to be the least attacked and will be tried in future. Type 21 was one of the types most severely affected by this disease in the previous season, and it appears that the incidence of disease in any particular type is subject to wide seasonal variation.

BRASSICAE

Representative cultures of different species of Brassicæ were grown both at Pusa and Karnal. A tentative classification has been made.

Brassicæ crosses. Some crosses between turnip and five Brassica varieties were made at Pusa and the F_1 s were grown at Karnal. The F_1 plants were intermediate in thickness of root and flowering time and had much more vigorous growth than either parent. The percentage of pods formed under bags in different plants of the F_1 generation was as follows :—

<i>Toria</i> (<i>B. napus</i> Linn. var. <i>dichotoma</i> Prain).	× Turnip (<i>B. campestris</i> subsp. <i>rapa</i>)	2.87 to 9.35
Turnip	× <i>Toria</i>	1.66 to 16.62
Turnip	× Yellow sarson (<i>B. campestris</i> Linn. var. <i>sarson</i> Prain)	4.69 to 77.12
Turnip	× Black sarson late (<i>B. campestris</i> Linn. var. <i>bliferu</i> Prain)	3.79 to 32.25
Black sarson late	× Turnip	0 to 12.4
Turnip	× Burma sarson (<i>B. oleracea</i> Linn. var. <i>chinesis</i> Prain)	2.15 to 60.00
Burma sarson	× Turnip	0 to 40.62

The cross between turnip and ordinary *rai* was not successful.

F_1 generations of crosses between yellow sarson and *toria* and yellow sarson and black sarson were also grown. Yellow sarson is a self-fertile species having yellow seeds, while *toria* and black sarson are both self-sterile with red seeds. F_1 plants were self-fertile with red seeds.

Statement showing the segregation of seed colour in F₂

Name of cross	No. of F ₁ plants	Frequency in F ₂		Total
		Red seed	Yellow seed	
Yellow sarson 75-1 × Toria 48-1	1	55	9	64
	3	21	5	26
	5	37	3	40
Total observed		118	17	130
Expected on 3:1 basis		97.5	32.5	
Toria 48-1 × Yellow sarson 60-1.5	1	28	9	37
	12	59	12	71
	17	31	6	37
Total observed		118	27	145
Expected on 3:1 basis		108.75	36.25	
Yellow sarson (60-1.5) × Black sarson	1	30	3	33
	3	40	7	47
	4	33	9	42
Black sarson × Yellow sarson	1	11	4	15
	4	49	2	51
Total observed		163	25	188
Expected on 3:1 basis		141	47	

It will be seen from the above results that the frequency of yellow-seeded plants is much less than the expected number. This may be due to the presence of a lethal factor in yellow-seeded plants and will be investigated during the course of detailed study.

To study the inheritance of sterility, fifteen plants in each F₁ culture were bagged and the percentage of pods formed was noted. Plants in which the percentage was below 30 were taken as sterile. The segregation of this character in F₂ is given below.

Statement showing the segregation of sterility in F₂

Name of cross	No. of F ₁ plants	Frequency in F ₂		Total
		Self-fertile	Self-sterile	
Yellow sarson × Toria	1	10	5	15
	3	14	1	15
	5	13	0	13
Total observed		37	6	43
Expected on 3:1 basis		32.25	10.75	

Name of cross	No. of F ₁ plants	Frequency in F ₁		Total
		Self-fertile	Self-sterile	
<i>Toria</i> × <i>Yellow sarson</i> 60-1-5	1 12 17	15 11 11	0 4 4	15 15 15
Total observed		37	8	45
Expected on 3 : 1 basis		33.75	11.25	
<i>Yellow sarson</i> × <i>Black sarson</i>	1 3 4	7 13 14	8 2 2	15 15 16
<i>Black sarson</i> × <i>Yellow sarson</i>	1 4	8 8	1 6	9 14
Total observed		50	19	69
Expected on 3 : 1 basis		52.5	17.5	

From the above results it is clear that red colour in seed coat and self-fertility are dominant over yellow seed coat and self-sterility.

These results confirm our former observations made on natural crosses. A type which has red seed with all other characters of yellow sarson has already been fixed, which means that by crossing a self-fertile species with a self-sterile one we can produce self-fertile types with some characters of self-sterile types.

III. SEED DISTRIBUTION

The following seeds were distributed from the harvest of 1932-33 :—

Wheat—		Mds.	Srs.
Pusa	4	115	2
"	12	105	0
"	80-5	43	25
"	111	23	5
"	112	7	20
"	113	8	0
"	114	13	35
"	120	5	38
"	165	5	38
Gram—			
T. 17		45	0
T. 58		32	10

IV. STATEMENTS SHOWING THE YIELDS OF CROPS

I. OUTTURN OF DIFFERENT CROPS DURING THE YEAR 1932-33

Crop	Plot No.	Area in acres	Actual outturn in lb.	Outturn per acre in lb.	Bushel-weight of 5 calculations in lb.	Highest outturn per acre in 1931-32 in lb.
<i>General Area—</i>						
Gram—T. 28	42	3.18	5,449	1,317		804
T. 53	44	1.90	3,971	2,090		
	45	1.80	5,264	2,925		896
Local	50	1.29	2,675	2,074		
	51	1.40	2,554	1,824		914
T. 17	46	1.70	4,243	2,497		1,136
	47	1.60	3,753	2,345		
	48	1.49	3,025	2,030		
	49	1.40	3,136	2,241		
<i>Wheat—P. 111</i>						
P. 80.5	1 to 5	4.63	7,624	1,646	64.4	1,419
P. 4	6 to 16	13.06	19,364	1,448	65.24	1,693
P. 114	17 to 23	16.47	24,052	1,460	63.3	1,437
P. 12	24 to 34	8.33	13,644	1,636	65.6	1,591
	35 to 41	15.50	26,143	1,665	62.9	1,166
<i>Oats—Hybrid J</i>						
B. S. 1	26	1.00	1,689	1,689	37.1	
	24, 26, 27, 28.	7.26	11,902	1,640	32.8	1,613
<i>Experimental Area—</i>						
Wheat—P. 135	1	1.09	2,575	2,362	45.8	2,052
	11	0.92	2,562	2,785		
P. 120	4	1.17	2,679	2,290	55.2	1,582
	10	1.44	2,538	2,226		
P. 112	3	1.17	2,591	2,214	64.1	1,339
P. 113	2	1.17	2,827	2,415	63.9	2,226
<i>Rice Area—</i>						
Local		3.79	1,312	346		
Nagpur		0.42	307	732		
T 14-1		0.96	553	576		
Fodder		0.91	7,732	8,497		
<i>Building Area—</i>						
Toria—local	1	0.63	732	1,076		
Sarson—local	2	0.84	1,363	1,624		
<i>Rice Area—</i>						
Red Rice	2	0.27				
	3	0.62				
	4	0.46				
		1.35	2,154	1,595		
<i>White Rice</i>						
	1	0.36				
	2	0.98				
	3	0.90				
	4	0.96				
		3.20	5,947	1,857		

2. OUTTURN OF PROMISING TYPES OF GRAM SOWN IN PLOT NOS. 5
AND 6 OF EXPERIMENTAL AREA

Types	Actual outturn in lb.	Area	Outturn per acre in lb.	Rank
T. 3	182	0·136	1,340	
T. 6	254	0·136	1,869	
T. 26	283	0·136	2,080	
T. 28	320	0·136	2,278	4th
T. 46	328	0·136	2,412	1st
T. 47	322	0·136	2,367	2nd
T. 48	193	0·136	1,416	
T. 49	195	0·136	1,432	
T. 50	266	0·136	1,959	
T. 51	289	0·136	2,125	
T. 53	295	0·136	2,171	
T. 54	281	0·136	2,064	
T. 66	287	0·136	2,109	
T. 67	328	0·136	2,412	1st
T. 69	190	0·136	1,402	
Local	320	0·136	2,351	3rd

REPORT OF THE SUGARCANE EXPERT

(RAO BAHADUR T. S. VENKATRAMAN, B.A., I.A.S.)

It is with profound regret that I have to record the passing away in February 1933 of Dr. C. A. Barber, C.I.E., the founder of the station. It is a great pity that he should thus have been snatched away at a time when the Indian sugar industry is rapidly expanding, primarily as a result of the activities of the station founded by him in October 1912.

I. CHARGE AND STAFF

I held charge of the office of Sugarcane Expert throughout the year. Mr. N. L. Dutt held charge of the post of Second Cane Breeding Officer till the 8th May when he left on nearly three months' leave.

The year's crop at the Karnal Sub-station was the first full year crop to be grown there. This sub-station is steadily taking shape and the bulk of the buildings was completed during the year.

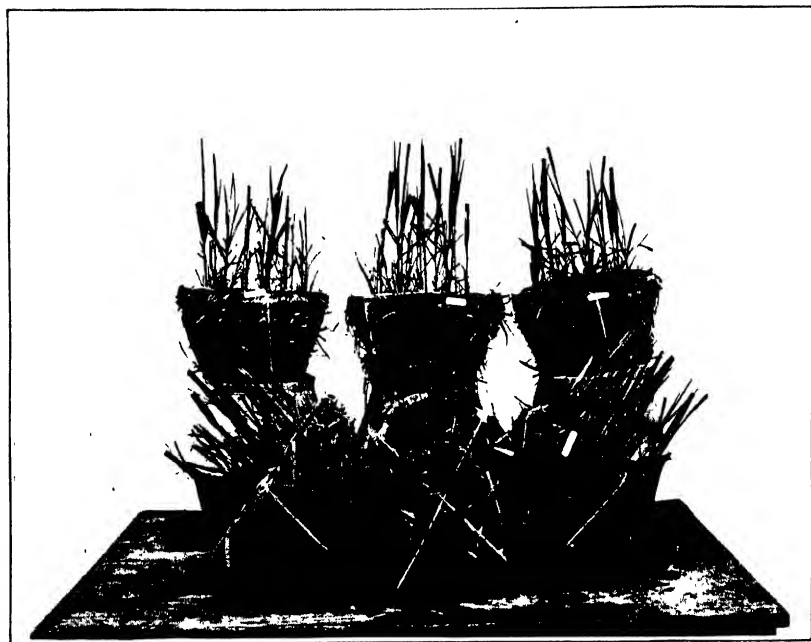
II. SUGARCANE BREEDING (MAINLY SUB-TROPICAL TYPES)

(a) BREEDING TECHNIQUE

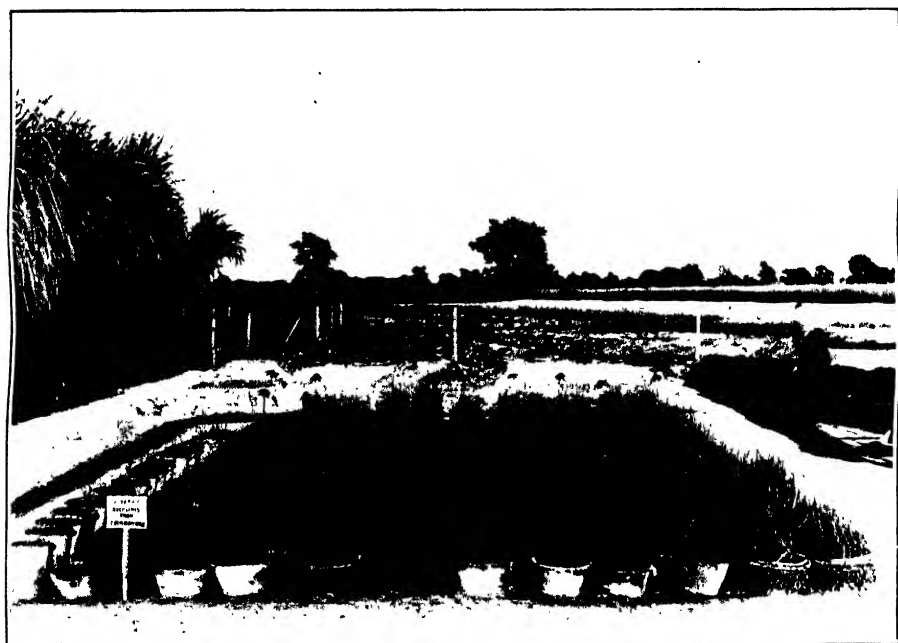
(i) *Controlling time of arrowing.* By planting at two seasons (*viz.*, December and April) and under different soil conditions (*viz.*, garden and wet lands), it has been possible to synchronize, for cross-fertilization purposes, the arrowing of most of the parents desired. A period of as many as 25 days was bridged over by this method.

(ii) *Preparing nursery seedlings for transport.* Some attention was devoted to the best manner in which seedlings could be transported as seedlings from Coimbatore to various stations in sub-tropical India. The object is to give the new seedlings a chance to grow under sub-tropical conditions even from the very early stages. After some experimentation it was found that one successful method was to partially starve the seedlings and prune them immediately before the railway journey. The earthen

PLATE III.



Young seedlings in earthen pans pruned and packed for railway journey



Batch of seedlings treated as in top picture after a railway journey of 72 hours over a distance of nearly 2,000 miles.

seed pans were protected by being wrapped round with paddy twist at the sides to avoid knocks and breakage during the journey. An attendant travelled with the seedlings to water them at railway junctions as needed. Thus transported, a batch of 5,000 seedlings showed very little mortality after a journey of 72 hours in a covered railway wagon provided with ventilators (Plate III).

(b) INTERSPECIFIC HYBRIDIZATION

(i) *Parents employed.* The arrowing during the year was satisfactory and enabled a large number of crosses to be made. P. O. J. 213, Co. 213 and Co. 221—pollen infertile mothers giving satisfactory germinations—were crossed with P. O. J. 2878, Co. 281, Co. 312 and Co. 313. From the parentages of the canes employed as parents, it will be seen that most of the resultant seedlings would have in their genetic composition the blood of at least three different species of *Saccharum*, one of them being *Saccharum spontaneum* and the second an indigenous Indian cane.

(ii) *Seedlings of the previous year.* Eleven thousand seedlings which completed their life-cycle during the year and consisting of hybrids between Co. 213, Co. 281, Co. 290 and Co. 313 were carefully studied and 39 selections made for further propagation and testing. It was found that Co. 313 introduced into the resultant seedlings good habit and satisfactory juice quality.

(c) INTERGENERIC HYBRIDIZATION

(i) *General.* Specimens of arrows of hybrids between P. O. J. 2725 and *Sorghum Durra* Stapf. were despatched to Kew, the meeting of the International Society of Sugarcane Technologists at Porto Rico and to Dr. Brandes at Washington. The specimens attracted some attention at the International Society and comment was made on the arrow characters and the comparatively large size of the seeds as compared with those in interspecific crosses. Mr. H. B. Cowgill, who has been specializing in the study of *Saccharums* and examined the Washington specimens, finds in the arrows " ample morphological evidence of their hybrid nature ".

(ii) *Parents employed.* Till the past season P. O. J. 2725 alone was employed on the mother side and *Sorghum Durra* Stapf. on the father side. During the current season it was possible to extend the range of parents on either side by the planting of parents at different times and under different soil conditions as

already mentioned. The parents employed during the season are given below :—

Sugarcane mothers

Sorghum fathers

P. O. J. 2725	.	.	<i>Sorghum Durra</i> Stapf.
P. O. J. 213	.	.	<i>Sorghum guineense</i> Stapf. Nigeria.
Co. 213	.	.	<i>Sorghum guineense</i> . Nigeria.
Co. 221	.	.	<i>Sorghum cernuum</i> . Palestine.
			<i>Sorghum halepense</i> . Palestine.
			<i>Sorghum halepense</i> . Coimbatore.
			<i>Sorghum verticilliflorum</i> Stapf.
			Uganda.
			<i>Sorghum sudanense</i> . Kansas,
			U. S. A.

Most of the above interesting *Sorghum* parents were kindly supplied by Mr. H. C. Sampson, Economic Botanist at Kew, to whom my thanks are due.

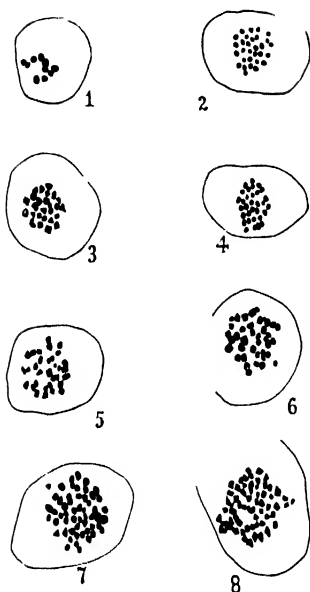
(iii) *Characters of the population.* The hybrid populations are showing quite a variety of forms, the bulk of them being very similar to sugarcane. The F_1 generation—which in the case of the sugarcane shows variations—while containing forms similar to the sugarcane does not include types very similar to the *Sorghum* parent. The populations often include quite a number of types which nestle close to the ground, show limited cane formation, possess thickish leaves and are obviously of no value as sugarcane. During the season as many as 8,000 such hybrids, representing various combinations, have been planted for a full year study. It would appear that cane parents other than P. O. J. 2725 are likely to give a better class of economic types.

(iv) *Back-crosses with Sorghum and Saccharum spontaneum.* Some of the hybrids between P. O. J. 2725 and *Sorghum Durra* Stapf. were back-crossed with *Sorghum Durra* Stapf. The resultant plants, while very interesting from the academic view point, do not appear to contain economic types. Some of these hybrids were crossed with the Coimbatore form of *Saccharum spontaneum*. The resultant plants are much like the thin-stemmed sugarcane.

(v) *Juice quality.* Certain features common to the selected hybrids between P. O. J. 2725 and *Sorghum Durra* Stapf. are (1) early fitness for milling under tropical conditions (from six to seven months), (2) further improvement in juice quality when

PLATE IV.

Wild Saccharums
(Polar view, Metaphase, Haploid)



and 2 Two different forms of *Saccharum munja*, 3 *Spontaneum* (Delhi, Dun), 4 *Spontaneum* (Godavery, Madras), 5 *Spontaneum* (Coimbatore, occurring on canal bunds), 6 *Spontaneum* (Dacca, Bengal), 7 and 8 Thin-stemmed and Thick-stemmed forms of *Spontaneum* (?) from Sumatra.



Badila

Co. 285

Co. 281

Badila

(at the Paddy Research Station, Aduthurai, Madras Presidency)

kept in the field leading to high sucrose values, and (3) comparatively high purities. One of these recorded over 23 per cent. sucrose in juice and a second over 21 per cent.

These hybrids often show a marked and rapid improvement in juice quality with the onset of conditions favourable to ripening (Table I).¹

TABLE I

*Analyses of sugarcane × sorghum hybrids at interval of a fortnight.
Age of crop at second round, 6 months and 3 weeks*

Variety	Date of analysis	Brix per cent.	Sucrose per cent.	Co-efficient of purity
	1932			
Co. 351 . . .	14th September .	16.75	13.18	78.7
	30th September .	18.99	15.78	83.1
Co. 352 . . .	14th September .	15.46	12.15	78.6
	30th September .	17.98	14.91	82.9
Co. 353 . . .	14th September .	17.14	13.96	81.5
	30th September .	19.59	16.49	84.2

III. RESEARCH AND INVESTIGATIONS

(a) CYTOLOGICAL STUDIES

One interesting investigation during the year was the study of chromosomes in (i) wild *Saccharums*, (ii) bud sports of Co. 213 and (iii) interspecific and intergeneric crosses with *Saccharums* by Botanical Assistant Thakur Suraj Narain Singh, who showed great diligence and enthusiasm for the work. He finds difference in the chromosome numbers of the different types now included under *Saccharum spontaneum* (Plate IV). In the previous report an account was given of the vegetative sports from Co. 213 and the manner in which they differed in their juice qualities and type of root-systems, the last being illustrated with photographs. Mr. Singh has now found differences in their chromosome numbers as well.

(b) SHOOT AND ROOT STUDIES

The periodic shoot weighments and root dissections of varieties under test mentioned in the previous report have yielded a method by which to select canes suitable to particular localities,

and it would appear important to study the manner in which the different varieties pass through the critical period for cane in the tract.

(c) INFLUENCING ARROW FERTILITIES

Sub-tropical canes like Sarethia and Chin which showed male sterility during the early years of acclimatization at Coimbatore had been developing abundance of fertile pollen in subsequent years. Fresh material of these canes was obtained during the year and planted under different soil conditions to try and discover the factors responsible for their male sterility during the earlier years.

(d) JUICE ANALYSIS OF VARIETIES UNDER TEST

It is not every sugarcane testing station that has full facilities for periodic analysis of the varieties under trial. Analyses at such stations are at present often dependent upon the ability and convenience of a central laboratory deputing one of the staff for carrying out the analyses. The experiment was therefore laid to find out if, by sending the canes properly packed and as railway parcels to a central laboratory, such analyses could not be done there. Results (Table II) show that there is little difference even after railway journeys extending over a period of three days. The preservation and packing of canes adopted in these sendings was the one described in a previous publication* (Venkatraman, 1920).

TABLE II

Juice analyses of sugarcane varieties before and after railway journey of three days

Variety	Brix per cent.		Sucrose per cent.		Co-efficient of purity	
	Before	After	Before	After	Before	After
Co. 366 .	17.01	16.89	14.56	14.32	85.6	84.8
Co. 380 .	19.77	19.90	17.39	17.63	87.9	88.6
Co. 370 .	17.31	17.19	15.03	14.79	86.8	86.1
Co. 376 .	19.15	18.84	16.76	16.42	87.5	87.1
Co. 341 .	18.45	18.49	16.04	15.78	86.9	85.4
Co. 374 .	20.94	20.90	18.97	18.91	90.6	90.5

*Agri. Jour. of India, Volume XV, Part 2 (March 1920).

IV. RESEARCH AND INVESTIGATIONS BEARING MAINLY ON THICK CANE BREEDING

(N. L. DUTT, M.Sc.)

(a) BREEDING

The bulk crossing during the year was of (1) *Vellai* × Co. 243, (2) P. O. J. 2878 × Co. 290 and (3) P. O. J. 2725 × 247 B. The first named combination has already given us the seedling Co. 402, which has been reported to have done well at several places. Besides, several other experimental crosses were made to ascertain the type of seedlings obtained.

(b) SELECTION OF SEEDLINGS

Out of 330 new seedlings grown in the test plots, five were raised to the status of Co.'s and their parentages are given elsewhere in this report (Co. 416 to Co. 420).

(c) CHROMOSOME NUMBERS

The haploid chromosome number was determined in the following varieties by making counts from the polar views of the equatorial plates of the pollen mother cells. In certain cases the number was confirmed by taking counts from diakinesis also. The varieties studied were Poovan, Chittan, Creole and Saretha. The last mentioned variety had an added interest in that it was expected to find in it the membranous body mentioned by Dr. Bremer as characteristic of the Indian canes. In quite a large number of sections examined, the characteristic body has not been found even in a single section. It is proposed to cut more sections before definitely coming to the conclusion that the body in question is absent in Saretha. Material has been fixed of Striped Mauritius, P. O. J. 1410, C. A. C. 87, Karun, Fiji B (Badila), and Kaludai Boothan.

(d) CHROMOSOME NUMBERS IN RELATION TO SIZE OF NUCLEI

Dr. Bremer has established a relationship between the haploid chromosome number and the size of nuclei of the pollen mother cells at diakinesis in certain varieties of *Saccharum officinarum* as also other forms of *Saccharum*. He found that if the radius of the microsporocyte in microns was raised to the third power, it

approximates to ten times the haploid number, *e.g.*, for Glagah, which has 56 haploid chromosomes, r^2 was 588 and 539 or not far from 560, that is, ten times the haploid number.

To ascertain the bearing of the above ratio on certain of the canes grown in India, measurements were made in Poovan, Chittan, Puri, *S. spontaneum* (Coimbatore) and Co. 205. The deviation from the above ratio was found to be over 70 per cent. in Poovan, *S. spontaneum* and Co. 205; and 27 per cent. and 50 per cent. respectively in Chittan and Puri. Subsequently measurements were also made in Saretha and the above ratio has been realized in this case. The haploid chromosome number in Saretha was found to be 46 and the r^2 came to 439 which is fairly close to ten times the haploid chromosome number.

(e) OBSERVATIONS ON MALE NUCLEI

The presence or otherwise of the four male nuclei in the seedlings of such canes as showed four male nuclei in previous years was pursued in greater detail. Four male nuclei were noticed in certain seedlings which contained the blood of B. 3412, P. O. J. 1410 and C. A. C. 87. In addition to the varieties already reported, four male nuclei were noticed in Co. 290, A. 2, Co. 223, D. 1135 and *S. spontaneum* (Coimbatore), though the occurrence of four male nuclei was rather rare in the three last mentioned varieties. Observations were made on the migration of male nuclei *in vitro* and *in vivo*. The migration was noticed to have taken place in a greater number of pollen tubes on stigmas in nature than in those growing in culture media.

(f) STIGMA RECEPTIVITY

Observations were made regarding the applicability of stigmatochromy for the determination of receptivity of the stigmas of certain sugarcane varieties. Stigmas were immersed in Robinson's argentiferous solution. The results were not conclusive and it is proposed to try different strengths of the solution next season.

(g) CONTROLLING TIME OF ARROWING

The main object in conducting this work is to increase the range of possible crosses. As reported last year, the flowering in the sugarcane was sought to be controlled by three methods, by topping, by subjecting to sub-normal day length and by etiolation. Results obtained in the last mentioned were not conclusive. Greatest success was, however, obtained with the second method.

P. O. J. 2725 and Co. 285 (early flowering varieties) were subjected to six hours and four hours day lengths for a period of 35 days and 45 days respectively. The treated canes flowered 14 days and 11 days earlier than the controls. The percentage of flowering in P. O. J. 2725 was 98 in the control canes and 76 in the treated canes, while in Co. 285, 75 per cent. of the canes flowered in the control and only 30 per cent. in the treated canes. It was also noted that the arrows in the treated canes were rather short. Confirmatory results were obtained with regard to the topping experiment and the results obtained during the current year are given in the following table. It is proposed next year to do the experiment on a larger scale in the varieties P. O. J. 2725, P. O. J. 2878 and Co. 285.

TABLE III

Results of topping experiment, 1932

Variety	Once topped		Twice topped		Control	
	Date of flowering	Percentage of flowering	Date of flowering	Percentage of flowering	Date of flowering	Percentage of flowering
P. O. J. 2725	21-9-32	72	24-9-32	74	15-9-32	84
P. O. J. 2364	30-9-32	90	28-9-32	70	26-9-32	74
P. O. J. 2878	4-10-32	80	16-10-32	37.5	1-10-32	85
Co. 285	30-9-32	93	5-10-32	65	28-9-32	73
Co. 290	8-11-32	78	7-11-32	63	6-11-32	86

(h) GERMINATION IN THICK CANE SEEDS

The variety Vellai was crossed with five different varieties to ascertain the influence of the pollinating parent on seed germination. Equally weighed quantities, 3 grms. per seed pan, were sown. It was found that the germinations in Vellai × Glagah and Vellai × Co. 205 were twelve and fifteen per pan respectively and eleven and eighteen for Vellai × Kaludai Boothan and Vellai × P. O. J. 2878 respectively. The best combination from this point of view was Vellai × B. 3412 which gave 246 germinations per pan. It was further found that Co. 403, a seedling of Vellai, gave better germination when crossed with P. O. J. 2878, as compared with the combination Vellai × P. O. J. 2878, the respective figures being 36 and 18 per seed pan.

V. RECEIPTS AND DISTRIBUTIONS

(a) RECEIPTS

The collection of *Sorghums* was reinforced by three types from Siera Leone, three from Kew and two from the Bombay Presidency.

(b) DISTRIBUTIONS

(i) *As true seed.* Preserved sugarcane seeds were sent to the Economic Botanist at Shahjahanpur in the United Provinces, to the Sugarcane Specialist at Mushari in Bihar and to the Sub-station at Karnal in the Punjab for sowing.

(ii) *As seedlings.* Five thousand seedlings of Co. 285 were sent to the Sub-station at Karnal in a special through wagon. Another consignment of 5,000 seedlings of parentages likely to be useful in the United Provinces were sent in a similar manner to the Sugarcane Research Station at Shahjahanpur.

(iii) *As canes.* Four hundred and twelve packets containing 84 varieties, mostly Co. seedlings, were distributed to various places in India and fifteen parcels sent overseas, viz., to Egypt, Kenya and Formosa.

VI. PERFORMANCE OF COIMBATORE CANES

(a) COIMBATORE CANES IN SUB-TROPICAL INDIA

The area under improved Coimbatore canes in the main sugarcane tracts of India is steadily on the increase. The official figures for 1932-33 are not yet available, but those for 1931-32 came to about 39 per cent. of the cane area. The increased yields from the Coimbatore canes combined with the wider range of conditions under which they are able to grow, constitute one important factor in the phenomenal development of the Indian sugar industry, particularly within the last two years.

Among the new canes, Co.'s 313 and 331 are perhaps the most promising, followed by Co. 299, Co. 326, Co. 301, Co. 244 and Co. 300. Co. 285 is justifying expectations entertained at the time of selection as likely to be an improvement on and replace Co. 205. In the farm at Patna this cane has shown considerable resistance

to conditions of water-logging. Among the latest productions, Co. 347, Co. 349 and Co. 350 are showing promise in the United Provinces.

(b) COIMBATORE CANES IN TROPICAL INDIA

It is hardly a couple of years since the first batch of Coimbatore seedlings of the thick type was distributed for trial and these are yet in comparatively small plots at the various stations. Preliminary reports about their performance have been quite satisfactory, Co. 402 and Co. 408 being apparently two of the most promising. In the preliminary test plots at Coimbatore, there are a certain number of the later seedlings showing better performance than the above two. In recent years hybrids have been raised between the best Coimbatore types and the best foreign canes like P. O. J. 2878 in connection with the breeding of improved canes of the thick class. The *jaggery* (crude sugar) of Co. 408 has shown very good quality followed by that of Co. 402. Largely through the personal interest of the present Director of Agriculture, Madras, use for the medium type of Coimbatore canes has been found even under Madras conditions. Even a comparatively thin medium cane like Co. 281 has yielded in certain localities in Madras higher tonnages than very thick types like Badila (Plate IV). The chief value of this class of canes in localities now under thick types would appear to lie in the comparative less care and attention they need and hence lower costs of cultivation.

(c) COIMBATORE CANES IN FOREIGN COUNTRIES

In South Africa, Co. 290 is reported to have yielded 31 per cent. more sugar than Uba and to be free from *sereh*. In Louisiana, Co. 281 has shown excellent keeping qualities on windrowing. In Porto Rico, Co. 281 has been found to be comparatively less susceptible to mosaic than P. O. J. 2878, Badila and B. H. 10 (12).

(d) SUGARCANE-SORGHUM HYBRIDS

Madras has probably got the largest data so far on these hybrids, due again to the personal interest of the Director of Agriculture, Madras. In certain of the stations these are planted every month and analysed periodically to find out the best way of fitting these short-duration canes into the agricultural programme of the tract. The first published report on these hybrids has been from Anakapalle, the Sugarcane Research Station for Madras (Table IV).

TABLE IV

Results of chemical analysis of sorghum crosses, 1931-32 (Sugarcane Research Station, Anakapalle, Madras)

Field No. 40.

Planted on 1st September, 1931.

Harvested on 9th April, 1932.

Variety	Brix per cent.	Sucrose per cent.	Glucose per cent.	Co-efficient of purity
Co. 351	19.57	17.44	0.31	89.10
Co. 352	20.47	17.90	0.31	87.46
Co. 353	17.17	14.27	0.69	83.12
Co. 354	18.67	16.08	0.64	86.12
Co. 355	17.17	13.92	0.80	81.08
Co. 356	15.37	11.75	0.82	76.45
Co. 357	17.97	14.95	0.68	83.20

The *gur* (crude sugar) obtained from most of these hybrids has been of a very satisfactory nature.

VII. THE KARNAL SUB-STATION

(Financed by the Imperial Council of Agricultural Research)

(a) GENERAL

The main object of starting this sub-station was to give scope to Coimbatore for testing under sub-tropical conditions whole series of new canes without preliminary rejections at Coimbatore and for obtaining first hand knowledge of growth conditions in North India. Along with this, it was also decided to explore the possibilities of obtaining viable seeds and of effecting crosses at Karnal itself.

(b) TESTING OF NEW CANES IMPORTED FROM COIMBATORE AS SETTS

The year's crop, considered one of the best in the tract, included 100 seedling canes (imported from Coimbatore as canes), which were grown for purposes of testing in ten to sixty rows (20 ft. long) according to the quantity of material available of each. Comparatively simple methods consisting, in the main, of periodic weighments of the above-ground portions and root dissections *in situ* were laid down for studying the merits of the new canes as

Compared with the *desi* or standard canes of the locality. These studies have led to useful results, certain of which are briefly described below :—

(i) *The life-cycles of the different varieties.* Besides germination and habit notes, two very important characters in a cane crop, periodic weighments were recorded of the shoot or above-ground portions of at least a whole row of canes to watch the manner in which the different varieties build up their tonnages at harvest. The data recorded included weight of the whole above-ground portion, number and weight of millable canes and quantity of juice obtained at harvest.

The local cane in the tract is Lalri, while Co. 205 and Co. 285 are the two Coimbatore canes that are replacing or are likely to replace the local variety. An examination of the data showed that Co. 312, Co. 357 and Co. 313 are easily superior not only to the local cane but also to Co.'s 205 and 285. Co. 357 is a hybrid between sugarcane and sorghum.

(ii) *Resistance to adverse summer conditions.* The severity of summer conditions in sub-tropical India is well known. As the canes are planted at the beginning of summer the manner in which a new cane withstands this period is a character of considerable importance in the selection of suitable types. Weighments of the above-ground portions of whole rows, once at the beginning of summer and a second time at the end of it, have yielded useful data on this point. Table V gives the figures for five of the best canes in this respect as compared with the local variety.

TABLE V

Manner in which different canes passed through the summer at Karnal

Seedling Number (1)	Weight of a whole row (above-ground portion) in lb.		Column 3 divided by Column 2 to indicate resist- ance to summer conditions (4)
	At beginning of summer (2)	At end of summer (3)	
Co. 317	4.5	68	15.1
Co. 312	10	118	11.8
Co. 341	10	84	8.4
Co. 205	12.5	88	7.0
Co. 285	12	68	5.7
Lalri	14	60	4.3

The statement shows the superiority of certain of the later Coimbatore productions in this respect. In pursuance of these results, a plot of unirrigated canes to test such seedlings has been laid for the next year.

(iii) *Maturity and juice quality.* Periodic refractometer readings were recorded from the beginning to end of the cane crushing season in the tract. This has yielded information on (1) the 'earliness' or 'lateness' of the varieties, (2) relative juice qualities and (3) period during which each variety maintains its juice quality without appreciable deterioration. It is felt, however, that conclusions from these data could be safely drawn only next season when the new canes will be grown in a larger number of rows. At harvest a complete juice analysis was made of the different canes under test.

(c) GERMINATION OF SUGARCANE SEEDS AT KARNAL

Of the 400 seedlings obtained in 1931 from seed germinated at Karnal, half a dozen showed satisfactory qualities, two of them being almost fit for distribution. These were from Co. 285 reported to be replacing the earlier cane Co. 205 in the Punjab. It was thought best, however, to get data on these new seedlings for yet another year and on a field scale before actual distribution.

(d) VIABLE SEEDS AT KARNAL

Examination of arrows revealed stray viable seeds in hardy canes like Co. 205 and Co. 326 when the arrows are put forth in March-April. It might later become possible to plant in such a manner as to delay the arrowing of parents till the approach of summer at Karnal.

VIII. PARENTAGES OF CO. SEEDLINGS

Parentages of seedlings raised to the status of Co.'s during the year are given in Table VI.

TABLE VI
Parentages of Co. canes

Seedling Number	Parentage
Co. 398	P. O. J. 2725 × <i>Sorghum Durra</i> Stapf.
Co. 399	P. O. J. 2725 × <i>Sorghum Durra</i> Stapf.
Co. 416	Vellai × Co. 243.
Co. 417	P. O. J. 2725 × Co. 290.
Co. 418	P. O. J. 2725 × Co. 290.
Co. 419	P. O. J. 2878 × Co. 290.
Co. 420	Karun × Co. 243.

IX. TRAINING

Two students from the Punjab, deputed by the Department of Agriculture of the province, joined for training in November 1932 for a one-year course.

X. MISCELLANEOUS

A set of herbarium specimens of sugarcane \times sorghum hybrids was sent to Dr. E. W. Brandes, Head of the Division of Sugar Plant Investigations, and another to Mrs. Agnes Chase of the United States Department of Agriculture.

XI. PROGRAMME OF WORK FOR 1933-34

MAJOR

The breeding of medium and thick canes will be carried on with the object of effecting further improvements, covering new tracts or cheapening cost of cultivation.

Attempts will be made to secure still better germinations among thick cane seeds.

Studies on the genetics of the sugarcane will be continued and extended with the help of the Geneticist sanctioned by the Imperial Council of Agricultural Research.

MINOR

Studies in sugarcane pollen, controlling time of arrowing and of the forms of *Saccharum* will be continued.

XII. PUBLICATIONS

- (1) Venkatraman, T. S., and Hussainy, S. A. Sugarcane Varietal trials for selecting suitable Improved Types. *Agri. and Live-stock in India*, Vol. III, Pt. I, page 1.
- (2) Dutt, N. L., and Subba Rao, K. S. Observations on the Cytology of the Sugarcane. *Ind. Jour. Agri. Sc.*, Vol. III, Pt. I, page 37.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(J. N. MUKERJI, B.A., B.Sc.)

I. CHARGE

Mr. J. N. Mukerji, Assistant Agricultural Chemist, held charge of the Section throughout the year.

II. EDUCATION

One post-graduate student finished his course in October 1932, and two are continuing their studies.

III. METEOROLOGY AND DRAIN-GAUGES

The usual meteorological records and records of drainage from four drain-gauges were maintained. In connection with drain-gauges, sann-hemp and wheat crops from the gauges and 24 samples of drainage waters were examined.

At the request of the Director General of Observatories, Poona, monthly averages of humidity at eight hours, and monthly averages of maximum and minimum temperatures at Pusa for ten years from 1921 to 1930 were worked out and supplied for the use of the Officer-in-Charge of Agricultural Meteorology. Besides these, other data, such as monthly rainfall for the last 27 years and drain-gauge percolation figures, were also supplied.

IV. GENERAL ANALYTICAL WORK AND ASSISTANCE GIVEN TO OTHER SECTIONS

1. GENERAL ANALYTICAL WORK

The following samples were analysed and reported upon :—

Soils	15
Manures	11
Feeding stuffs	32
Oil-seeds	125
Sugarcane	307
Milk	865
Water.	1
Drugs	10
Miscellaneous	14

Besides those made in connection with the work of this Section, the analyses made for other Sections of the Institute and for persons outside Pusa are indicated briefly as follows. For the Agricultural Section, nine samples of manures, one of silt, 203 of sugarcane in connection with the farm's variety test, manurial experiments, etc., 28 of feeding stuffs, and 835 of milk were analysed. The milk samples from two leading cows and two lowest yielders in the herd were examined twice every alternate day in order to see the variation in the fat content under special handling. These cows were milked four times daily with equal intervals between milkings and were kept on low concentrates. For the Botanical Section, 125 samples of linseed, two of manures, three of wheat, 10 of *ganja* (Indian hemp), and one of commercial formalin were analysed. The wheat samples were examined for their starch, gluten, and maltose contents; the diastatic activity and gas production with regard to their baking qualities were also determined. The gas production from wheat flour which was bleached by Novadelox process was much less than that from (1) wheat dry cleaned and unconditioned and (2) wheat conditioned and tempered for milling. Bleaching by a chemical agent thus had the bad effect of reducing the gas production. Besides these, chemical analysis of 8 composite samples of soil taken from the areas under the Botanical Sub-station at Karnal, and mechanical analysis of 36 individual samples from the same area have been completed. For the Mycological Section, 36 samples of sugarcane from the mosaic tonnage plot, four of soil, and four of fungal cultures were examined, and for the Entomological Section, 66 samples of sugarcane were analysed in connection with the damage done by topshoot borers, stem-borers, root-borers and termites, individually and collectively.

Five samples of soil were received from the Agricultural Officer, North-West Frontier Province. The three from Peshawar, though rich in manurial constituents, contained an abnormally high percentage of water-soluble salts and two from Bannu were deficient in phosphoric acid content. Two samples of soil, received from the Deputy Director, Land Records and Agriculture, Coorg, were found very poor in lime content, and one of them was also deficient in phosphoric acid. Two samples of sweet sorghum from the Sugarcane Specialist, Sugarcane Research Station, Mushari, contained about 5 per cent. sucrose and 1 per cent. glucose in juice. Eight samples of *ganja* (*Cannabis sativa*) received from the Excise Commissioner, Bihar and Orissa, were examined for their specific rotation and resin content with a view to find out their physiological activity, and five samples of barley malt received from the Manager, Solon Brewery, were examined for diastatic activity, colour of wort, and cold water extract.

EXAMINATION OF METHODS OF ANALYSIS

(i) The estimation of sucrose in bagasse by Noel Deerr's method, using the bagasse digester, was tested to see if it was applicable in case of bagasse obtained from a three-roller mill. The 45 minutes digestion at boiling temperature as recommended in this method was found insufficient to extract all the sugars from the coarsely cut bagasse pieces. The time of digestion for complete extraction was found to be at least one hour.

(ii) Helige Pehameter for determining the pH value of soils in the field was tested with Jorhat soil, to which had been added increasing proportions of lime, and also with Solon soil and Pusa soils. The values of pH obtained by it deviated from those obtained by the quinhydrone electrode method by 0.2 to 0.3. For field work the apparatus is likely to prove useful.

(iii) *Estimation of potassium.* The method suggested by Hibbard and Stout (vide *Journal of Association of Official Agricultural Chemists*, Vol. 16-I, 137-140), which is based on the precipitation of potassium as *potassium cobaltinitrate* by a cobaltinitrite reagent in the presence of 2 per cent. acetic acid solution, filtration of the fine precipitate through a bed of talc powder (specially treated and made free from organic matter), its subsequent oxidation by (0.01N) KMnO_4 solution and titration of the excess KMnO_4 by a standard sodium oxalate solution, was tried in this laboratory and found to give fairly accurate results within certain limits. The method, however, is not reliable in the case of solution containing more than 5 mg. of potassium. Hibbard and Stout found that estimation of potassium by this method is possible in the presence of small quantities of difficult soluble substances as calcium sulphate and silica, but it has been found in this laboratory that even the presence of fairly large quantities of soluble ferric, calcium and magnesium salts (all of which are present in soil or plant extracts) as impurities does not interfere with the determination or with the result.

The authors have directed to add the potassium cobaltinitrite precipitate to a boiling solution of KMnO_4 but this procedure gives a slightly higher figure (as shown below) owing to the dilute (0.01N) KMnO_4 slightly losing its strength, when boiled in the presence of H_2SO_4 .

K in mg. found by estimation	1.13	2.28	2.29	3.77	5.54
K in mg. actually present	1.05	2.10	2.10	3.67	5.24

If, however, instead of adding the cobaltinitrite precipitate to a boiling solution of KMnO_4 , a few cubic centimetres of the latter are run into the beaker containing the precipitate and then heated in the waterbath till decomposition is complete, better results are

obtained, even in the presence of ferric, calcium and magnesium salts as impurities, as is evident from the figures given below.

K in mg. found by estimation	1.97	3.90	4.90	9.40
K in mg. actually present	2.00	4.00	5.00	10.00

If in the above results, the factor for 1 c.c. of (0.01 N) KMnO_4 be taken as equivalent to 0.0639 mg. K instead of 0.0625 mg. K, as suggested by Hibbard and Stout, almost theoretical results are obtained (*vide* table below).

K in mg. found by estimation using factor 1 c.c. $\text{KMnO}_4 = 0.0639$ mgK.	2.006	3.975	4.996	9.730
K in mg. actually present	2.000	4.000	5.000	10.000

V. RESEARCH

1. CROPS

Experiment on curing of tobacco. It was reported last year that the method of curing by picking the leaves from the stalk is more expensive and requires more space than the method of curing the leaves with stalks on. By the former it is possible to harvest all the leaves at the right stage of maturity, but with the latter it is not. The leaves on the plant do not all ripen at the same time so that the stalks are cut at such a time as will give the greatest number of the best leaves at the proper stage of ripeness. This causes a considerable sacrifice in both bottom and top leaves since the former are over-ripe and the latter still immature. In many cases, both methods are said to give satisfactory results when properly carried out and the question as to which is the better in any given case must be decided largely by the local conditions, such as the amount and kind of the labour supply, the barn space available, and the like. Although either method may give good results, there are undoubtedly differences in the character of the cured product. To understand the differences brought about by the two methods, it must be remembered that the leaves and the stalks remain alive for several days or even weeks after harvesting, depending on the condition in the curing shed. During this period of gradual starvation they are enabled to remain alive by means of the reserve food supply stored up during the ripening process, so long as they retain sufficient moisture. When the leaves are cured on the stalk, there is a movement of food materials from the leaves into the stalk, but when the leaves are picked, there is, of course, no chance of this movement from leaf to stalk to take place. The longer curing period and the movement of materials from the leaf into the stalk when curing on the stalk is practised, will affect the quality of the cured tobacco.

In order to ascertain the difference in character, two lots of tobacco, each of Adcock and Pusa Type 28, as already reported last year, were cured on racks by both these processes and the cured products were examined for their nicotine, sugar, starch, ash potash, amido nitrogen and albuminoid nitrogen contents. These constituents have been recognized by several investigators to possess a direct bearing on the quality of tobacco, and attention was therefore confined to the examination of these for studying the differences. Last year tobacco leaves cured with stalks on invariably showed a higher nicotine content than leaves cured without stalks. The starch and sugar contents, on the other hand, as evident from Table I, are invariably lower in the case of tobacco leaves cured with stalks than those cured without stalks. Owing to a longer curing period and to movement of food materials from the leaf to the stalk, there is, thus, in the case of leaves cured with stalks a greater destruction of the two carbohydrates than in leaves cured without stalks.

The amido nitrogen in tobacco represents, for the most part, harmless or even beneficial nitrogenous compounds and the conversion of albuminoids into amides is one of the most important results of the curing and fermentation. The albuminoids by themselves afford no indication of quality unless the proportion of amides is simultaneously considered. Similarly a high content of potash in tobacco will not improve its fireholding capacity unless it is present mostly in combination with organic acid together with a minimum amount of inorganic salts. Hence the ratio of albuminoid nitrogen to amido nitrogen, and the ratio of ash to potash, in tobacco will indicate its quality more properly than each of these constituents considered separately. A lower ratio in both cases will thus indicate a better quality and a higher ratio an inferior quality of tobacco.

An examination of Table I shows that curing tobacco leaves with stalks invariably tends to lower the albuminoid-amide ratio, but in most cases it raises the ash-potash ratio.

TABLE I

Description of tobacco	Method employed in curing	Nicotine	Starch	Total sugar	Albuminoid Nitrogen	Amido Nitrogen	Albuminoid N	Ash	Potash	Ash Potash
Adcock, harvested on 25th January 1932.	Leaves cured without stalk.	% 2.13	% 6.88	% 8.33	% 1.13	% 0.195	5.81	% 17.30	% 1.63	10.61
Ditto . . .	Leaves cured with stalk .	2.82	6.08	5.95	1.17	0.205	5.71	20.63	1.47	14.07
Adcock, harvested on 27th February 1932.	Leaves cured without stalk.	4.12	5.07	5.05	1.25	0.250	5.02	22.45	1.29	17.44
Adcock harvested on 1st March 1932.	Leaves cured with stalk .	5.37	1.28	2.76	1.18	0.370	3.18	23.01	1.52	15.16
Pusa Type 28 harvested on 18th February 1932.	Leaves cured without stalk.	3.61	1.64	4.24	1.05	0.285	3.68	19.79	1.73	11.41
Ditto . . .	Leaves cured with stalk .	4.67	0.83	1.85	0.95	0.315	3.00	22.39	1.58	14.16
Pusa Type 28 harvested on 1st March 1932.	Leaves cured without stalk.	4.46	1.15	2.55	0.92	0.245	3.77	23.12	1.52	15.23
Ditto . . .	Leaves cured with stalk .	5.35	1.01	2.36	0.84	0.245	3.43	21.89	1.23	17.82

Potato storage experiment. Mr. P. B. Sanyal continued the experiment on the storage of potatoes. Past and present experiments in potato storage have shown that the rotting of the potato is more dependent on the increase of temperature of the storage places than on the bacterial or fungus infection in the initial stage, for at high temperature potatoes rotted even after effective treatment by fumigation with carbon disulphide or by steeping in copper sulphate solution.

It was further shown that the incidence of rotting in the potato is due to the shortage in oxygen supply to the tissues of the tubers which are stimulated to greater activity at a higher temperature. At lower temperature the diffusion of oxygen through the tissue appears to be sufficient for its respiration but when the temperature rises the rate of diffusion of oxygen cannot keep pace with the increased activity of the tissues and consequently they succumb with the destruction of the vital enzyme such as *catalase* and black heart and black spot appear in the tubers. At this stage, it appears, the bacteria or fungi that are always associated with the tubers, or are present in the atmosphere and storage places, attack the dead tissue and produce heart rot.

The whole problem of storage is, therefore, not to allow the tubers to be stimulated to greater activity during storage. Attention was therefore directed during last year to store potatoes in open pits of different depths in shade where the temperature is somewhat less than that of the atmosphere during summer months. Accordingly, freshly dug out potato tubers were sorted into two sizes, *viz.*, medium and small, and both stored on sand in underground pits of 3', 2½' 2' and 1½' depth and also, for comparison, on the ground and on a bamboo shelf 3' above the ground level. Maximum and minimum temperatures of these storage places were recorded daily throughout the storing period. The results of the storage experiment, as stated in Table II, show that in the case of the medium-sized potato the rotting was greatest in the storage pit 3 ft. deep and was less as the depths of the storage pits decreased, though the temperatures of the deeper pits were in no way higher than those of the shallower ones or of the ground. The rotting was more conspicuous during the damp months of August, September and October when the tubers had sprouted than during March to July when the atmosphere was comparatively drier. This clearly shows that a humid atmosphere as is generally met in underground pits during the monsoon is quite unsuitable for storage purposes.

In spite of the higher temperature of the ground, the loss in weight of potato due to rotting was only 3·5 per cent. of the weight of the freshly dug potatoes, while in a 3-ft. deep pit it was as high as 33 per cent. The rotting of potatoes on the bamboo shelves was 9 per cent., this being evidently due to the higher temperature of the shelf than that of the ground. These results, therefore

lead one to infer that, like temperature, moisture also stimulates the tissue activity in the potato, as is evident from the vigorous sprouting of the tubers in the storage pits.

In the case of the small-sized potatoes, the results show that they are less susceptible to temperature and moisture variations and therefore preserve better. This is probably due to their larger surface (weight for weight) which radiates heat more quickly and allows less deposition of moisture on the surface. The loss of small-sized potatoes due to rotting at different storage places varied between 2.8 and 15.2 per cent., while that of the medium ones 3.5 to 33 per cent. The loss due to drying in the case of the smaller tubers was, however, greater than that of the bigger ones, the average being 53.4 and 47.8 per cent. respectively.

Considering the effect of both temperature and moisture, the smaller tubers preserved better than the bigger ones, the loss being 39.3 per cent. and 34.7 per cent. respectively. For seed purpose too, the smaller tubers are preferable and more economical in as much as the requirement for planting the same area is less than half that of the medium ones.

TABLE II.

Storing places	Medium tubers			Small tubers		
	Rotted	Pre-served	Dried	Rotted	Pre-served	Dried
	%	%	%	%	%	%
Pit 3 ft. deep . . .	33.05	23.75	43.20	2.78	42.90	54.32
„ 2½ ft. deep . . .	19.50	34.96	45.54	15.22	24.40	60.38
„ 2 ft. deep . . .	13.30	35.28	51.42	6.94	46.30	46.76
„ 1½ ft. deep . . .	16.84	38.38	44.78	8.95	46.45	44.60
Ground	3.47	46.47	50.06	6.03	34.72	59.25
Bamboo shelf 3 ft. high	8.88	32.50	58.62	4.32	40.90	54.78
TOTAL	17.47	34.75	47.78	7.39	39.27	53.34

The suitability of tubers, from different storing places, for seed purpose was tested by actually sowing them and comparing their germination. The seeds preserved on the ground and those on

bamboo shelf were more sound and gave good and uniform germination. It therefore clearly appears that for seed purpose the potato should be protected from higher temperature as well as from humid atmosphere and there should be sufficient air for their respiration.

Effect of manures on sugarcane juice. The manurial experiment with sugarcane carried out in 1932-33 was designed to see the effect of mineral manures like superphosphate of lime and sulphate of potash on the quality of sugarcane grown with an organic nitrogenous manure as oil-cake. Previous experiments with single artificial and nitrogenous manures showed that the latter when applied to sugarcane increases the yield but the quality of juice from it is inferior. No definite conclusion could be arrived at from some previous experiments carried out in 1929-30 in single 1/20th acre plots. It was therefore decided to lay out the above experiment in four replications for each treatment in a Latin square. The following treatments were adopted for the purpose :— (1) Mustard cake at 100 lb. N per acre, (2) Mustard cake at 100 lb. N, with sulphate of potash at 50 lb. K_2O per acre, (3) Mustard cake at 100 lb. N, with superphosphate of lime at 100 lb. P_2O_5 , and (4) Mustard cake at 100 lb. N, *plus* superphosphate of lime at 100 lb. P_2O_5 , *plus* sulphate of potash at 50 lb. K_2O per acre. The area of each plot was 1/40th acre and the space left out between different plots was 6 feet. The manure was applied in two doses, *viz.*, 1/3rd at planting and 2/3rd at the time of earthing. The cane grew well. Periodic analyses of the samples of 10 standing canes drawn at random from each plot were carried out once a month from November to February. The crop was harvested in early February and the yield in maunds per acre worked out for each of the 16 plots. The mean yields for different treatments have statistically no significance.

Experiment on the quick availability of natural indigo for dyeing purpose. Natural indigo from Bihar is prepared into dry cakes for the market and contains about 60 to 65 per cent. indigotin. It can not be used for dyeing purpose readily. The cake has to be ground into a very fine powder, converted into a paste of uniform consistency and reduced by bacterial action or by reducing agents to indigo white (which is soluble in water), before it can be used for dyeing purpose. Finally the cloth dyed in the indigo white, on exposure to atmosphere, is oxidised by the oxygen of the atmosphere, and the indigo white changes to indigo blue. Indigo, whether natural or synthetic, is insoluble in water and it has to be reduced to indigo white, which is soluble, before it can be used for dyeing purpose. For the reduction of indigo to indigo white readily, one of the necessary conditions is to bring the indigo into the form of a paste of uniform consistency, with the particles remaining in suspension in as fine a state as possible or in other words it should be brought into a colloidal state.

With a view to bring the natural product into a readily available form and in a line with the synthetic dye, some preliminary experiments in this laboratory are being carried on on the following lines—

- (1) Preparation of indigo paste of definite strength or rather “the standardisation of the paste”.
- (2) Bringing the indigo paste into a colloidal state by means of chemicals.
- (3) To stop fermentation of such paste by means of antiseptics which may not interfere with the strength of colour or with the process of subsequent reduction.
- (4) To stop fermentation of such paste by heating or sterilizing it at high temperatures without diminishing the strength of colour.

The work was taken up in January last when no indigo in the form of natural paste was available. Experiments, therefore, so far were carried on with indigo paste prepared from cake powdered into a very fine state and mixed with water of equal weight.

With a view to bring the paste into a colloidal state and to stop fermentation of such paste when kept in sealed tins, treatment with sodium carbonate in the proportion of 1 per cent., 1·5 per cent., 4·5 per cent. of the indigo paste, and subsequent heating of the paste in a water bath for 8 hours at 80°C. were tried. 1 per cent. and 1·5 per cent. sodium carbonate proved totally ineffective, in as much as the paste fermented very badly within four days. Treatment with 4·5 per cent. sodium carbonate, however, stopped fermentation to a good extent, without in any way diminishing the indigotin content or destroying the strength of colour. The addition of sodium carbonate in the proportion of 1·5 per cent. of the weight of paste, and subsequent heating at 120°C. under 1 atmosphere pressure for 40 minutes in an autoclave, proved successful and completely stopped fermentation. The same result was obtained by treatment with 1·5 per cent. sodium carbonate and subsequent heating in an air oven at a temperature of 105°C. for 12 to 15 hours. In none of these latter two treatments, there was any change or destruction of the indigotin. The contents of the sealed tins when opened and examined after three months were found to be unchanged and free from fermentation. The work is in progress.

2. SOILS AND FERTILIZERS

Lime requirement of acid soils. Mr. S. Das continued the investigation on the lime requirement of acid soils during the year. Earlier work had confirmed the inadequacy of the existing laboratory methods as a quantitative measure of lime requirement of acid soils. In order to ameliorate acid soil conditions and to collect correlative data for laboratory studies, pot experiments

with an acid soil from Jorhat Experiment Station, Assam, were carried out by adding $1/3$, $2/3$, $3/3$, 2, 3, and 4 times the lime required to bring the pH of the soil to 7. The amount of lime to bring about the neutrality of the soil was found by drawing a titration curve by means of the quinhydrone electrode on adding increasing quantities of standard lime water to a known amount of soil. About two months after the filling of the pots wheat was grown in them.

There was a corresponding series of uncropped pots from which samples of soil were periodically drawn for laboratory studies. pH was determined in these soil samples from time to time. It has been found from the values of pH obtained that a considerable time must elapse after the addition of lime to an acid soil before an equilibrium in soil reaction can be attained. This is in accordance with observations of workers in other parts of the world. It depends not only on the nature and amount of the soil acidity, but also on the kind of liming materials used and prevailing climatic conditions.

In the cropped pots the growth of wheat was not so satisfactory as anticipated, and consequently no definite conclusions can be drawn from the yield. It may, however, be observed that when pH of the soil mixture approaches neutrality or goes beyond 7.0, the wheat plants hardly tend to bear any seed. Apart from the acid character of the Jorhat soil, deficiencies of food materials are perhaps acting as limiting factors for proper plant growth in this soil. In the next crop of *ragi* (*Eleusine coracana*) grown during this monsoon, deficiencies regarding food materials have been eliminated by adding basal dressings of nitrogen, phosphate, and potash to these pots at the rate of 80 lb. of the first two and 40 lb. of the last one per acre. The crop is progressing well at present and its harvest will be watched with interest.

✓ *The effect of potash on yield in calcareous soils.* The apparent ineffectiveness or even depressing effect of potassic fertilizers has been observed in several field experiments conducted at Pusa. With a view to find out if the ineffectiveness or depression indicated in the field trials at Pusa with potassic fertilizers is due directly to potash or due to some other indirect cause, such as the interaction of the sulphate of potash with the calcium carbonate present in the soil and thereby producing a condition unfavourable to the growth of plants, five small plots of equal area in duplicates as already reported were laid out last year. Three of these plots in duplicates were treated with potassium sulphate and potassium chloride respectively. The fourth one in duplicate had received calcium sulphate and the fifth one in duplicate was left untreated to serve as control. *Eleusine coracana* was sown in all these plots as a *kharif* crop and it was followed by wheat as a *rabi* crop.

As no significant result could be obtained from plots in duplicates, the experiment was extended in October last over 25 newly laid out small plots of equal area, with five replications for each treatment. Wheat was sown in all the 25 plots in November last and the crop harvested in March. It is too early to draw any conclusion from the yield of one season and the experiment has to be continued for several seasons before any definite conclusion can be arrived at.

Limiting factor of phosphate requirements in calcareous soils. It is well known that the growing plant itself possesses more or less power to feed directly on phosphates and that some plants possess specially marked powers. As a result, no common limiting figure for available phosphoric acid can be suggested as given by Dyer (*Jour. Chem. Soc.* 65, 155, 1894) which will be equally applicable to all types of soil, for the figure varies not only with the character of the soil, but also depends on the kinds of crops grown. Consequently, this figure must be worked out for different soils, and it will vary even in the same soil according to the type of crop grown on it from time to time.

The problem becomes further complicated by virtue of the common experience of the ordinary cultivator that different types of soil require different systems of manuring. Although calcareous soils round about Pusa yield extremely low values of available phosphoric acid when measured by ordinary laboratory methods, the action of phosphatic manures on them in actual farm practice is extremely erratic. As for instance, the application of superphosphate alone, more often than not, yields disappointing results, and the best yields are usually obtained when applied in conjunction with heavy organic manures.

Therefore, with a view to discover the limiting factor of phosphate requirements in calcareous soils, two series of pot experiments have been started with a calcareous Pusa soil which, although containing originally 2,100 lb. of total phosphoric acid (P_2O_5) per acre, gives very low values of available phosphate with ordinary analytical methods of the laboratory. In one series nitrogen has been applied at the rate of 100 lb. per acre as sulphate of ammonia and potash (K_2O) at 80 lb. per acre as sulphate of potash, and in the other series dried green manure applied to supply similar amounts of nitrogen and potash per acre. Phosphate has been added in both the series in the form of precipitated calcium phosphate at the rate of 25, 50, 100, 200, 400, 800, and 1,600 lb. P_2O_5 per acre. *Eleusine coracana* has been grown in all the pots. Two corresponding series of uncropped pots have also been started side by side to supply periodically samples of soil for laboratory studies.

Study of soils of tobacco tracts in India. Soils of various tracts in India where tobacco is extensively cultivated vary very widely from one another both in physical and chemical characters. These soils are either black heavy (regur), red laterite, sandy, or fine silt. Some of these are of acid character and some alkaline. With a view to find out common factors, if any, which influence the growth and yield of this crop, a study of both the physical and chemical characters of typical tobacco soils of various parts of India have been taken up. The soils that are under examination for this purpose are those from (i) the Kaira District in Northern Gujarat, specially from Nadiad, Anand, Petlad, Borsad and Baroda, from places where either tobacco is grown under unirrigated condition, or grown under irrigation with well waters usually containing a considerable amount of nitrate of potash; (ii) Broach District in Southern Gujarat, specially from the *bhatta* lands on the river Nerbudda, where tobacco is grown under unirrigated conditions and without application of manure; (iii) the district of Rangpur in Bengal and (iv) North Bihar, where tobacco is extensively cultivated under unirrigated conditions. In connection with this work it is intended to obtain other typical soil samples from the districts of Guntur, Trichinopoly and Madura in the Madras Presidency, from the district of Belgaum in Bombay, and from Cooch Bihar and Jalpaiguri, specially from the tracts on both sides of the river Tista, in Bengal.

Nitrifiability and manurial value of apricot seed-cake in soils. In continuation of the experiments reported last year, Mr. S. Das further investigated the nitrogen transformation of the apricot seed-cake in a hill soil from Solon near Simla Hills, containing a fair amount of organic nitrogen, e.g., 0.15 per cent., which is about three times as much as present in Pusa and Kalianpur soils studied last year, but is not so easily nitrified as in the other cases. The cake, however, nitrified more quickly in this soil. As for instance, 58 per cent. nitrogen of the cake is transformed into available forms in four weeks' incubation in it, whereas in Pusa and Kalianpur soils 63 per cent. was transformed in 7 to 8 weeks' time.

On critically examining the curves of nitrate and ammonia formation for the three soils, it is noticed that initially a high proportion of ammonia is formed from the cake in all cases, the immediate depressing effect of which is apparent on the formation of both nitrite and nitrate. This effect dissipates in about two weeks' time in the case of Kalianpur and Solon soils, where the evolution of ammonia is much less than that in Pusa soil, but it persists for a longer period of about four weeks in the latter and retards the formation of nitrate. Boulanger and Massol (*Ann. Inst. Past.* 17, 492—515, 1903; 18, 181—196, 1904; *Compt. rend. Acad. Sci.* 687, 1905) found that the growth and activity of nitrate bacteria is not injured by the ammonium salt but by free ammonia. This depressing effect appears to have been further accentuated by the

presence of a bitter principle in the cake itself which precludes its use as a cattle food. The chemical examination of the cake revealed the presence of 0.057 per cent. of hydrocyanic acid which is high enough to prove fatal to cattle.

The content of hydrocyanic acid may be attributed to the presence of some cyanogenetic compound in the apricot seed-cake, which may be either a glucoside or an alkaloid. The hydrocyanic acid coupled with free ammonia evolved from the cake, is very likely to adversely effect the normal activities of nitrate and other bacteria in the soil. This point is under further study in the laboratory.

The availability of about 60 per cent. of the nitrogen present in the cake renders it possible as supplying a suitable nitrogenous manure to the soil. To test this point, a set of pot experiments was conducted with a calcareous Pusa soil, where wheat was grown as *rabi* (winter) crop in 1932. Nitrogen was applied to a group of 4 pots for each treatment at the rate of 20, 40, 80, and 100 lb. per acre in the form of apricot seed-cake. The yields of wheat obtained were submitted to Fisher's method of analysis of variance and the results between treatments were found to be significant even for one per cent. level of significance. The application of 80 lb. of nitrogen per acre as apricot seed-cake to Pusa soil gave practically the maximum crop production, 100 lb. of nitrogen per acre, however, yielding a slightly better crop, though not statistically significant. It would thus appear that apricot seed-cake can be successfully used in ordinary farm practice as a suitable nitrogenous manure.

Eleusine coracana has been grown as a *kharif* crop in the above pots where wheat was grown, in order to study the residual effect of the manure, if any. Two fresh series of pot experiments have also been started to evaluate the primary effect of the cake in Kalianpur and Solon soils. *Ragi* has been grown in these pots and the same procedure of manurial treatment as in the case of Pusa soil has been followed.

VI. RESEARCH PROGRAMME FOR 1933-34

(1) *Study of the soils of tobacco tracts in India.* Physical and chemical examination of typical tobacco soils already obtained from North and South Gujarat, from North Bihar, and from Rangpur District in Bengal will be continued. Typical tobacco soils from the districts of Guntur, Trichinopoly and Madura in Madras and from Cooch Bihar and Jalpaiguri in Bengal will be obtained for the purpose of this study.

(2) *Nitrogen balance in Indian soils.* The analysis of soils and crops from the nine permanent manurial plots under different treatments of manuring will be completed and examined for the purpose of constructing a nitrogen balance sheet for the different systems of manuring.

(3) *Lime requirements of acid soils.* Attention will be concentrated on the examination of the cropping power of an acid soil by means of pot experiments after the addition of incremental quantities of lime in proportion to its lime requirement with basal dressings of nitrogen, phosphate, and potash. *Eleusine coracana* has been grown as a *kharif* crop in an acid (Jorhat) soil under varying liming treatments for the purpose. There is also a corresponding series of uncropped pots side by side to supply samples of soil for periodical examination in the laboratory.

(4) *Effect of potash on the yield of crops.* The yield of *kharif* and *rabi* crops from the 25 small experimental plots, in replications of five for each treatment, will be recorded, and will be submitted to Fisher's method of analysis of variance in order to find out the significance of the results. The soils after each harvest of *rabi* crop will be examined for their manurial constituents.

(5) *Limiting factor of phosphate requirements in calcareous soils.* With a view to discover the limiting factor of phosphate requirement in calcareous soils two series of pot experiments have been instituted with a calcareous (Pusa) soil to which precipitated calcium phosphate has been added in amounts varying from 25 to 1,600 lb. of P_2O_5 per acre. In one series inorganic nitrogen as ammonium sulphate and in the other organic nitrogen as dried green manure at the rate of 100 lb. nitrogen per acre have been applied in order to study at the same time the effect of mineral and organic nitrogenous manures on phosphate manuring in these soils.

6. *Nitrifiability and manurial value of apricot seed-cake in soils.* An investigation into the manurial value of the cake will be made in Solon and Kalianpur soils by means of pot experiments with *Eleusine coracana* as the *kharif* crop. The residual effect of the manure, if any, will be similarly studied by pot experiments with the Pusa soil where the cake was applied to grow wheat during the last winter.

7. *Effect of manures on sugarcane juice.* The effect of oil-cake (mustard cake) alone, and in combination with either superphosphate of lime or sulphate of potash or both, will be further studied on sugarcane grown in Latin square plots in replications of four for each treatment. The canes will be periodically analysed from November till harvest, when the yield will be recorded and the fibre in cane determined, in addition to ordinary juice analysis, in order to get an idea of the total sugar in each plot.

8. *Storage of potatoes.* Experiments on the storage of potatoes will be continued in a dry and cool place. Laboratory experiments will be conducted to find out if the beginning of heat rot in potato is due to bacterial or enzymatic action.

9. *Standardisation of indigo paste and its prevention from fermentation.* Experiments in this connection so far have been carried with natural dry indigo cake converted into paste. Natural

indigo paste as available immediately after *makai* will be brought to and maintained at a definite concentration in respect of indigotin content. Various chemical antiseptics and methods of sterilisation by heat, which should not destroy the indigotin or interfere with its subsequent reduction to indigo white, will be tried in order to prevent fermentation of the standardised paste when kept in sealed tins.

VII. PUBLICATIONS

- Das, S. The Effect of Gypsum on Calcareous Soils. *Agri. and Livestock in India*, Vol. III, Pt. II, March 1933.
- Hossain, M.A. Disintegration of Bones by Alkali method and their use as Fertilizers. *Agri. and Livestock in India*, Vol. III, Pt. II, March 1933.

REPORT OF THE PHYSIOLOGICAL CHEMIST

(F. J. WARTH, D. SC. (BIR.), B. SC. (LOND.), I. A. S.

I. CHARGE

Mr. A. Viswanatha Iyer held charge of the Section until the 9th November, 1932, on which date I took over charge.

II. LABORATORY WORK

The following is a list of analyses completed during the year :

Complete analyses—

1. Fodders	44	
2. Faeces	80	
		124
Dry matter in faeces, urine, fodders, etc.		2,229
Single nitrogen determinations in fresh faeces, fodders, urine, etc.		647
Mineral analyses of urine, fodders, faeces, etc.		258
Complete analyses of urine		97
Miscellaneous analyses		255
Total		3,610

III. RESEARCH WORK OF THE SECTION

1. EXPERIMENTS ON THE NUTRITION OF GROWING ANIMALS

An experiment on mineral feeding to growing animals has been carried out. Two groups consisting chiefly of 18 months old heifers were given identical rations in every respect, except that one group received a mineral supplement and the other group received no supplement. At the end of twelve weeks there was no visible difference between the two groups. In condition they were similar, food consumption and live-weight increase for the two groups were more or less the same.

*Average daily consumption (in kilogrammes) per head and live-weight
(in pounds)*

Week	Group "A" (mineral supplement)				Group "B" (no mineral supplement)			
	Consumption			Live weight	Consumption			Live weight
	Rough-age	Concen-trate	Total		Rough-age	Concen-trate	Total	
1	3.916	1.243	5.159	420	4.273	1.240	5.513	440
2	4.190	1.293	5.483	426	4.470	1.291	5.761	447
3	4.121	1.232	5.353	436	4.211	1.222	5.433	454
4	4.148	1.246	5.394	443	4.332	1.269	5.601	461
5	4.501	1.250	5.751	449	4.701	1.268	5.969	469
6	4.559	1.273	5.832	..	4.898	1.277	6.175	..
7	4.559	1.273	5.832	465	4.898	1.277	6.175	480
8	4.573	1.289	5.862	470	4.878	1.297	6.175	487
9	4.578	1.296	5.874	477	4.909	1.306	6.215	493
10	4.328	1.307	5.635	481	4.901	1.332	6.233	496
11	4.371	1.308	5.679	487	4.821	1.315	6.136	503
12	4.520	1.314	5.834	496	4.979	1.327	6.306	512

The figures show that both groups consumed their rations with regularity and made regular progress in live-weight increase.

The results for the two groups are almost identical in every respect, and it must be concluded that the mineral supplement had no perceptible effect either on growth or condition.

It may be noted that the food consumption was unusually satisfactory amounting to 27.2 and 27.7 lb. dry matter per 1,000 lb. live-weight for groups A and B respectively.

The live-weight increase, 76 lb. for group A and 72 lb. for group B, is also very satisfactory.

This ration has given good results in every respect and does not need a mineral supplement.

Hence 0.73 per cent. CaO and 0.47 per cent. P_2O_5 in basal ration suffice for normal growth. Actual assimilation of minerals from the two rations was determined during digestion trials. The following results were obtained :—

Assimilation of minerals average per day in grams

	Group "A"		Group "B"	
	P_2O_5	CaO	P_2O_5	CaO
Intake	32.13	50.84	33.26	54.94
Outgo	25.96	44.15	28.03	45.17
Balance	+6.17	+6.69	+5.23	+9.77

From the above it may be noted that there is no appreciable difference in the assimilation of CaO and P_2O_5 between the two groups. Blood of animals from the two groups was also tested for Ca and P , and it was found that, except for slight individual variations, the two groups showed no difference.

2. EXPERIMENTS ON MILK PRODUCTION

As mentioned in the last report, an experiment on high and low protein rationing to cows has been undertaken in collaboration with the Dairy Section. After certain set-backs the work is now proceeding satisfactorily. It is impossible to draw definite conclusions at this stage. It appears, however, that the composition of the milk is not perceptibly affected by the difference in feeding practice. Some typical figures bearing on this point are given in the accompanying table.

Composition of milk with high and medium protein ration

	Total solids per cent.		Ash per cent.		Protein per cent.		Fat per cent.		Sugar per cent.	
	High	Medium	High	Medium	High	Medium	High	Medium	High	Medium
7.3.1933 .	13.020	12.366	0.695	0.744	2.904	2.872	4.5	4.1	4.8	4.38
2.4.1933 .	12.698	12.260	0.679	0.737	2.888	3.015	4.5	4.2	4.56	4.5
6.6.1933 .	12.389	12.493	0.703	0.750	3.090	3.261	4.25	4.5	4.6	4.4

There is an indication, which requires confirmation, that the higher protein ration prolongs the lactation period slightly. On the other hand, with the high protein unfavourable effects on the cows are suspected. It is evident that the experiment must be continued for a long time to make the conclusions clear on these points.

3. INDIAN COARSE FODDERS

This work has been continued on the lines indicated in previous reports. Tests are in progress at present with some typical Mysore hay samples. The effect of the stage of maturity upon composition and digestibility is being studied with this material.

Tests with certain *juar* (sorghum) samples have been completed. In this case two stages of development, representing respectively the prime and the ripe crop, were examined. In each series feeding experiments were carried out both with the fresh fodder as it came in from the field and with identical material converted into hay. Some very interesting results have been obtained in this work. The accompanying table shows that, in every case, conversion into hay has led to a notable increase in the "crude fibre" fraction and a corresponding serious lowering of digestibility of the carbohydrates.

	Crude fibre		Soluble carbohydrates	
	Per cent. Crude fibre	Digestibility co-efficient	Per cent. Soluble carbohydrates	Digestibility co-efficient
Prime <i>juar</i> . . .	35.3	61.9	48.9	62.0
Prime hay . . .	39.4	60.6	42.7	43.7
Ripe <i>juar</i> . . .	36.9	61.8	49.9	57.6
Ripe hay . . .	40.9	57.4	45.5	44.2

Similar effects have been obtained by the Nutrition Section in earlier experiments. The data relating to *juar* are being selected for publication.

A chemical enquiry may also be referred to appropriately here. Experiments have been undertaken to compare the carbohydrates of four typical fodders, viz., rice straw, *ragi* (*E. coracana*) straw, *juar* straw and hay. The question is whether marked physical differences exist between the carbohydrates of such distinct products possessing distinct digestibility co-efficients.

4. EXPERIMENTS WITH LEGUME HAYS

This is a new line of work undertaken by the Nutrition Section. There is no doubt that legume hays are very valuable as cattle food. Very little work has been done on this subject in India. The present experiments are of a tentative nature to study the preparation of such hays, to determine their digestibility and to observe their effect on the nitrogen balance. In all, six types of hay were made. Of these, only four, viz., groundnut hay, cowpeas hay, cluster-beans hay and soya-bean hay were successful. All will be made again this year and with the experience that has been gained and the modifications that have been introduced both products are confidently expected. Emphasis is laid on this enquiry because it is most desirable to encourage the production and utilization of legumes for animal nutrition in India.

5. MINERAL REQUIREMENTS OF CATTLE

Last year an experiment was reported and published in which the minerals provided by two fodders, viz., *ragi* straw and mature hay, were compared, using mature bullocks for the test. This year a similar experiment has been completed in which rice straw and *juar* hay have been tested and compared. The method of experimentation was exactly the same as that employed in the former series of tests. The two fodders were first tested without a mineral supplement. This was followed by a period of mineral feeding. Finally there was a period in which mineral and green grass supplements were given. The intention in the last test was to determine whether green grass vitamins could bring about further mineral assimilation. The experimental work and the analyses have been completed but the data are not yet fully worked out. The following table shows the average results obtained for each period.

	Rice straw		<i>Juar</i> hay	
	P_2O_5	CaO	P_2O_5	CaO
1st period . . .	+0.09	-2.42	+3.12	+2.61
2nd period| . . .	+4.41	+0.74	+2.06	+2.72
3rd period . . .	+3.25	+4.26	+2.12	+5.01

From the above figures it may be concluded that rice straw provides just enough P_2O_5 but not enough lime. In the second period when the ration was supplemented by calcium phosphate

there was appreciable assimilation of lime and phosphoric acid and both showed a positive balance. During the third period there was no marked assimilation of P_2O_5 but an increased assimilation of lime is visible.

With regard to *juar* hay, as there was a sufficiency of both lime and phosphoric acid, there was not any marked difference in the assimilation of lime and phosphoric acid during the first two periods, but an increased assimilation of lime was noticeable in the third period. This emphasizes the previous observation that a mineral supplement has no appreciable effect in cases where there is enough present in the fodders themselves.

6. INDIAN PASTURE GRASSES

As explained in the previous reports, this work is intended to give comparative values of the mineral composition of grasses grown on selected typical soils in various parts of India. Some of the latest results are shown in the accompanying table.

Percentage mineral composition of grasses grown at different centres

Stage of maturity	Pusa (Bihar)			Poona (Bombay)			Sabour (Bihar)			Bangalore (Mysore)		
	Before flowering	In full bloom	Dead ripe	Before flowering	In full bloom	Dead ripe	Before flowering	In full bloom	Dead ripe	Before flowering	In full bloom	Dead ripe
<i>Andropogon contortus</i>	Ash.	9.27	9.65	8.14	12.00	10.93	11.43	9.29	No sample.	12.57	10.93	8.59
	Ash soluble in Hcl .	4.00	3.72	2.91	3.76	2.02	3.62	2.60	No sample.	8.18	7.25	3.67
	P ₂ O ₅	0.266	0.218	0.228	0.164	0.059	0.331	0.402	No sample.	0.628	0.428	0.188
	CaO	0.649	0.589	0.835	0.363	0.389	0.365	0.525	No sample.	0.603	0.558	0.403
	MgO	0.280	0.315	0.250	0.340	0.240	0.280	0.282	No sample.	0.407	0.417	0.225
	Na ₂ O	0.315	0.288	0.381	0.282	0.167	0.392	0.318	No sample.	0.168	0.273	0.295
	K ₂ O	1.863	1.307	0.742	1.626	1.337	1.240	1.586	No sample.	3.861	3.206	1.511
	Crude Protein . .	4.439	4.630	3.163	6.370	4.975	3.620	5.988	No sample.	15.100	10.925	4.863
<i>Andropogon annulatus</i>	Ash	13.37			11.10	13.37	11.99	7.76	No sample.	11.60	12.01	8.89
	Ash soluble in Hcl .	8.54			2.99	3.35	3.32	3.43	No sample.	7.02	5.08	4.58
	P ₂ O ₅	0.529			0.214	0.269	0.176	0.502	No sample.	0.508	0.474	0.302
	CaO	1.205			0.459	0.418	0.390	0.807	No sample.	0.876	0.762	0.436
	MgO	0.324			0.249	0.282	0.320	0.204	No sample.	0.377	0.269	0.428
	Na ₂ O	1.046			0.331	0.247	0.264	0.161	No sample.	0.648	0.529	1.486
	K ₂ O	4.078			1.136	0.990	1.017	0.907	No sample.	3.058	1.826	1.553
	Crude Protein . .	9.037			5.276	7.944	3.469	3.016	No sample.	14.681	11.893	8.275
<i>Pennisetum Cenchrus</i>	Ash	21.21	12.50	12.63	4.85	23.73	13.95	12.84	14.17	13.49	11.72	9.22
	Ash soluble in Hcl .	15.58	8.54	6.53	4.63	5.25	5.33	6.01	6.20	9.20	7.77	5.19
	P ₂ O ₅	0.537	0.419	0.399	0.226	0.206	0.765	0.575	0.815	0.671	0.501	0.306
	CaO	1.266	0.628	0.770	0.500	0.597	0.486	0.552	0.555	0.432	0.436	0.480
	MgO	0.641	0.375	0.393	0.611	0.722	0.167	0.320	0.276	0.368	0.432	0.451
	Na ₂ O	0.594	1.166	1.421	1.126	1.021	1.275	1.392	1.112	1.360	1.083	1.173
	K ₂ O	8.935	3.985	2.558	0.662	0.608	1.925	1.905	2.612	3.887	3.050	1.620
	Crude Protein . .	10.763	9.175	6.281	14.213	10.456	5.823	9.231	6.175	14.369	11.913	7.056

Looking into the figures it is seen that different varieties of grasses grown at the same place show marked differences in their composition, as also the same variety grown at different places. But looking at the figures of the three varieties grown at Bangalore, this is not borne out by the figures evidently due to other factors exerting their influence. Another observation is the known fact that the mineral contents vary with the stage of maturity, the dead ripe stage producing very poor quality. More data are being collected and when these are completed, they will form the subject of a more detailed publication.

While the main question in this work relates to minerals subsidiary information on the characteristics of some pure species of grass is being collected incidentally. For example, it has been found that the protein content is a specific character. The figures given in the table illustrate this fact very clearly.

7. EXPERIMENTS WITH SHEEP

The work in hand at present is concerned with the influence of rationing on wool production. The experiments are in a preliminary stage and it is not possible to give any figures.

8. PHYSIOLOGICAL STUDIES

Work on hippuric acid, phenols, and acid base balance, as outlined in previous reports, has been continued. Work on blood analysis has made considerable progress. The procedures have been improved and standardised and some data have been collected. Comparing *ragi* straw and mature *juar* rations the following figures for blood Ca and P were obtained from two animals on these two rations.

	Gopal		Jaya		In mg. per 100 c. c. plasma
	P	Ca	P	Ca	
<i>Ragi</i> straw . . .	3.79	9.95	3.90	9.99	
Mature <i>juar</i> . . .	5.23	9.40	5.77	8.60	

Juar evidently gives higher blood P and calcium about the same for the two rations.

In a mineral feeding experiment with calves considerable individual variations of blood calcium and phosphorus were noted. With such animals it will probably be necessary to carry out tests by reversal of rationing.

Glycuronic acid excretion. It has been found that conjugated glycuronic acid is present in all urine samples of our cattle and sheep. The quantity varies very materially according to the nature of the fodder. A recent test has proved clearly that glycuronic acid conjugation is not concerned with a substance which can be detoxicated alternatively by sulphuric acid. Two

sheep were fed the same ration of cake, grass and hay. One of these animals received a sulphate supplement. The urine showed the following characteristics :—

	Sheep 1	Sheep 2
Glycuronic acid (yield of Furfural in grm.) . . .	0.138	0.156
Sulphate excretion (grm. BaSO ₄ per day) Total . . .	5.00	1.80
Sulphate excretion (grm. BaSO ₄ per day) Free . . .	3.00	0.00

That is to say, even when the sulphate is very greatly increased there is little change in the glycuronic acid output.

Sulphur and sulphate balance experiments. Following up work published last year (*Indian Journal of Veterinary Science and Animal Husbandry*, Volume II, Part III, September 1932), it has been shown again that the sulphur balance is favourably influenced by injection of inorganic sulphate. Of four sheep fed identically in other respects, two received a supplement of sodium sulphate and the other two received no supplement. The sulphur balances for the four animals were found to be as follows :—

	Sulphate supplement		No supplement	
	No. 1	No. 2	No. 3	No. 4
Sulphur balance as grm. BaSO ₄ per day.	+0.437	+0.316	—0.146	—0.065

These are striking and very significant figures. The work is proceeding.

IV. CO-OPERATION WITH OTHER DEPARTMENTS

As usual, grasses, hays and crops raised by the Military Farms Department are being tested.

With the Mysore Department, co-operation work on legume hay and pasture grasses is proceeding and joint work on blood analysis of typical animals has been arranged.

V. LECTURES TO STUDENTS

As usual, lectures on chemistry and animal nutrition have been provided for the Dairy Diploma students.

VI. PUBLICATIONS

The following papers were published during the year under report :—

1. Sulphur and Sulphate Balance Experiments with Cattle, by F. J. Warth. *Ind. Jour. Vet. Sc. and Animal Husb.*, Vol. II, Part III, September 1932.
2. The Quantitative Production of Benzoic acid and Phenols in the Animal System, by F. J. Warth and N. C. Das Gupta. *Ind. Jour. Vet. Sc. and Animal Husb.*, Vol. II, Part III, September 1932.

3. The Conjugation of Benzoic Acid by Indian Cattle, by N. C. Das Gupta. *Ind. Jour. Vet. Sc. and Animal Husb.*, Vol. II, Pt. III. September 1932.
4. An Experiment to determine the effect of Hippuric Acid excretion on the Nitrogen Balance, by F. J. Warth and N. C. Das Gupta. *Ind. Jour. Vet. Sc. and Animal Husb.*, Vol. II, Part III. September 1932.
5. The Influence of Urinary Reaction on excretion of Lime and Magnesia, by N. Krishna Ayyar. *Ind. Jour. Vet. Sc. and Animal Husb.*, Vol. II, Part III, September 1932.
6. An Experiment on Mineral Assimilation from two typical Fodders, by F. J. Warth, A. Viswanatha Iyer and N. Krishna Ayyar. *Ind. Jour. Vet. Sc. and Animal Husb.*, Vol. II, Part IV, December 1932.
7. A Preliminary Experiment on the digestion of fats by bullocks, by P. A. Seshan. *Ind. Jour. Vet. Sc. and Animal Husb.*, Vol. II, Part IV, December 1932.
8. Silage Investigations at Bangalore, III—Effect of the stage of maturity on the Ensilage of *Juar*, by T. S. Krishnan. *Agri. and Livestock in India*, Vol. II, Part V, September 1932.
9. Silage Investigations at Bangalore, IV—Ensilage of *Juar* Straw, by T. S. Krishnan. *Agri. and Livestock in India*. Vol. II, Part VI. November 1932.
10. Relative merits of high and low Silage Feeding to Cows in Milk, by the Post-graduate students. *Agri. and Livestock in India*, Vol. III, Part II. March 1933.

VII. PROGRAMME OF WORK FOR 1933-34

MAJOR SUBJECTS

1. Experiments in the nutrition of growing animals.
2. Experiments on milk production, including mineral assimilation.
3. A study of Indian coarse fodders, including maturing tests.
4. Indian pasture grasses: a survey of their mineral composition.
5. Blood analysis.
6. Preliminary respiration work.
7. Sheep-feeding experiments.
8. Physiological studies.

• MINOR SUBJECTS

1. A study of the chemical methods employed in the above enquiries.
2. Preliminary experiments for the initiation of work on other aspects of nutrition.

REPORT OF THE IMPÉRIAL MYCOLOGIST

(W. McRAE, M.A., D. Sc., F. L. S.)

(1) MYCOLOGICAL SECTION, PUSA

I. CHARGE

Dr. M. Mitra was in charge of the Section until the 29th December 1932 when Dr. McRae resumed duty as Imperial Mycologist and Director on return from officiating as Agricultural Expert to the Imperial Council of Agricultural Research. Assistant L. S. Subramaniam was appointed Assistant Sugarcane Mycologist with effect from 23rd June 1933, under the scheme for research in mosaic and other diseases of sugarcane financed by the Imperial Council of Agricultural Research.

II. TRAINING

An Agricultural Overseer of the Bihar and Orissa Department of Agriculture received training on diseases of the potato crop and methods of controlling them. Mr. G. S. Kulkarni, Special Cotton Mycologist, Dharwar, worked in the section for three months and help was rendered to him in the writing up of his cotton wilt report.

III DISEASES OF PLANTS

(i) PIGEON-PEA

Fusarium vasinfectum on *Cajanus indicus*. The resistant capacity of Type 80 was again tested in the fifteen Punjab permanent manurial plots (A series) and 22 deaths occurred as compared with three during the last year, while during 1928-29 when ordinary mixed farm seed was sown in the plots the wilted plants numbered 5,656. A paper entitled "Influence of Manures on the Wilt Disease of *Cajanus indicus*" is being published as Scientific Monograph No. 7 of the Imperial Council of Agricultural Research.

(ii) SUGARCANE

Mosaic disease. The whole area of fifty-five acres under sugarcane in the farm was rogued and the varieties affected with

the disease, together with the area under cultivation, as compared with that during the previous three years, were as follows :—

Variety.	1929-30		1930-31		1931-32		1932-33	
	Area in acres	Percent- age of in- fection	Area in acres	Percent- age of in- fection	Area in acres	Percent- age of in- fection	Area in acres	Percent- age of in- fection
Co. 210	13.0	0.005	8.2	Nil	10.44	0.01	16.27	0.017
Co. 213	6.7	0.13	8.	0.001	9.77	0.05	14.12	0.003
Co. 281	..	..	..	..	2.71	0.006	12.48	0.2
Co. 299	2.04	0.03	0.6	0.02	1.39	0.01	2.57	0.1
Co. 302	..	..	0.6	0.03	..	..	..	..
Co. 303	..	..	1.25	0.005	0.85	0.01	..	..
Co. 313	0.31	0.002	..	..	..	..	3.06	0.005

In all there were 14 varieties under field trial and 43 varieties in the nursery. All these varieties, except those mentioned above, were free from the disease during the year.

In the experiment laid down in February 1933, to test the natural spread of mosaic disease where a row of each of the 43 varieties alternated with a row of Co. 213 mosaic-infected cane, all the varieties tested remained free from infection up to the end of June. The varieties tested were :—Saretha, Chunnsee, Co. 210, 213, 214, 281, 285, 290, 299, 300, 301, 302, 303, 312, 313, 316, 317, 318, 319, 327, 331, 332, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 355, 356, 357, Tuco 393, Tuco 472 and P. O. J. 2878.

Tonnage experiments. A paper entitled "Effect of Mosaic on the tonnage and the juice of sugarcane in Pusa, Part II", giving the result of the last year's investigation, was published, and the experiment was continued. Thirty-six plots each 5 by 56 yards of Co. 213 were laid down in adjacent pairs, half of them with mosaic-free and half with mosaic cane in the order mosaic-free, mosaic, mosaic, mosaic-free and so on. The area was good and suitable for growing sugarcane. Great care was taken to select the canes for planting. A small amount of infection spread to the mosaic-free plots, and altogether seven clumps were found to have the disease in six plots. Thus the mosaic-free plots were substantially free from infection as such small numbers have a quite inappreciable effect on the weight of the stripped cane. This small spread to healthy cane in plots in such close juxtaposition to mosaic infected cane as they are, indicates how few and how inactive insects were during the season in spreading the disease.

The mean percentage of infection with insects was slightly more than that of last year and as follows :—

Insects	Mosaic-free	Mosaic
Top shoot borers (<i>Scirpophaga nivella</i> Fabr.)—		
Early attack	10·9	10·5
Late attack	26·02	26·7
Stem-borers (<i>Argyria stictica</i> Hmpn. <i>Diatraea venosata</i> Wlk., <i>Chilo zonellus</i> Swinh.)	4·35	4·36
Root-borer (<i>Emmalocera depressella</i> Swinh.)	9·29	9·2
Termite	9·5	8·58

The mean difference in each case is small and has no statistical significance. Whatever loss was caused by these insects was so evenly distributed that it did not have any effect on the difference of the mean tonnage of the plots. No damage was done to the canes either by fungi or by animals. Before harvesting the cane it was noticed that the stand of cane at the extreme end of the block was much thinner than in the rest of the block. Termites in the latter part of the growing season had been more active there. A row of low trees had been cut out in the previous season along the roads a few yards from the sides of the block, and experience has shown that the termites are liable to be more numerous till the roots decay and it may be considered that the two end plots, both mosaic-free, did not show the relative difference in yield between their corresponding mosaic plots that might be due to the presence of the disease. It was considered that the unequal damage caused by white ants that had destroyed the cane was likely to make the difference due to disease. It was accordingly decided that leaving the two end pairs of plots out of account would provide a set of sixteen pairs that would be a truer representation of the facts. After removing cane to eliminate edge effect the plots were five by fifty yards and the yield of stripped cane in maunds (82·28 lb.) was as follows :—

Weight in maunds (82·28 lb.) of stripped cane of Co. 213

Mosaic-free	Mosaic	Mosaic-free	Mosaic
38·26	38·58	47·26	52·41
41·70	44·20	52·92	47·84
47·72	45·69	52·45	49·90
45·53	40·53	50·53	48·99
42·39	40·31	50·30	51·42
47·98	49·90	47·73	45·55
46·16	49·43	42·85	45·16
47·63	46·98	41·00	41·86
Mean 46·40	46·17		
Difference 0·23			

Samples from all plots were analysed by the Imperial Agricultural Chemist and the details are given below

Plot Nos.		Weight of cane in lb.		Weight of juice in lb.		Percentage weight of juice to cane		Brix corrected		Sucrose per cent.		Glucose per cent.		Purity per cent.	
F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.
4	3	301	322	201	213	66.7	66.3	16.59	17.77	12.68	14.24	1.04	0.85	76.44	80.15
5	6	261	344	173	210	66.3	61.1	17.73	17.69	14.60	14.39	0.86	0.78	82.32	81.32
8	7	419	431	315	298	75.2	63.4	17.59	17.37	14.20	13.87	0.86	0.86	80.71	79.82
9	10	380	377	279	272	73.5	71.9	17.76	17.75	14.34	14.45	0.85	0.78	80.73	81.39
12	11	386	336	282	223	72.9	66.4	18.37	17.90	14.90	14.41	0.84	0.81	81.10	80.52
13	14	408	430	278	297	68.6	69.1	16.93	17.43	13.18	14.08	1.06	0.83	77.83	80.74
16	15	483	456	333	276	68.9	60.5	17.71	17.74	14.22	14.33	0.95	0.93	80.29	80.75
17	18	407	386	279	254	68.7	65.9	17.46	17.86	13.94	14.60	0.99	0.84	79.85	81.74
20	19	346	427	237	294	68.4	68.8	17.69	17.34	14.20	13.73	0.95	0.92	80.25	79.18
21	22	420	391	292	279	69.5	71.1	17.62	18.30	14.08	14.97	1.04	0.85	79.92	81.81
24	23	367	353	252	237	68.6	67.3	18.07	18.33	14.58	14.80	1.06	0.91	80.67	80.75
25	26	397	374	274	258	69.0	68.9	17.81	17.03	14.22	13.33	1.04	1.06	79.96	78.37
28	27	422	379	293	261	69.4	68.9	17.01	16.36	13.31	12.32	1.16	1.16	78.24	75.29
29	30	439	311	311	212	70.8	68.1	17.36	18.50	13.27	15.01	1.17	0.86	76.46	81.12
32	31	364	405	248	283	68.1	69.7	18.53	18.39	15.23	14.94	0.74	0.79	82.16	81.24
33	34	370	377	256	252	69.2	66.9	18.91	17.93	15.64	14.40	0.67	0.93	82.71	80.30
Mean		385.6	381	268.9	257.4	69.61	67.14	17.696	17.73	14.16	14.24	0.95	0.88	79.97	80.28
Difference		-4.6		-11.5		-2.47		+0.034		+0.08		-0.07		+0.31	

The statistical figures calculated by "Student's method" to determine the significance of the difference in yield between the series of pairs of plots are summarised below :—

Co. 213	Mean difference	Standard deviation	Mean difference	Odds
			Standard deviation	
Cane yield	0.23	2.8	0.08	0
Juice	11.5	38.0	0.3	6:1
Percentage juice to cane . .	2.47	3.64	0.67	77:1
Calculated juice per plot . .	1.3	2.6	0.5	27:1
Brix	0.034	0.51	0.06	0
Sucrose	0.08	0.84	0.1	2:1
Glucose	0.07	0.12	0.58	36:1
Purity	0.31	2.1	0.15	2:1

Thus the difference in the percentage of juice to cane, the calculated juice to cane and the glucose are alone statistically significant. This year then in the mosaic plots the weight of the stripped cane and the quality of the juice had not deteriorated, indeed there was slightly less glucose. However, four per cent. less juice was extracted from the cane in the mosaic plots.

Survey. In July 1932, an attempt was made to get a better appreciation of the intensity of mosaic infection in the cane fields of North Bihar. The Deputy Director of Agriculture, North Bihar Range, co-operated in the survey by allowing three overseers of his staff to work with three assistants of the Mycological Section at Pusa and by planning the details of the tour. The method of sampling was to take narrow strips in different fields in each of the selected sixty-five localities and to record the total number of clumps of cane and the number of clumps infected, in order to get the percentage of infection. On looking at the map on which the places examined are plotted the sample as a whole presents a fairly representative picture of the position in North Bihar with regard to the intensity of mosaic disease. The

summary of the record for this and the two previous seasons in which a survey was made is as follows :—

Variety	1927			1931			1932		
	Area of strips examined	No. of localities	Percentage infection	Area of strips examined	No. of localities	Percentage infection	Area of strips examined	No. of localities	Percentage infection
Co. 213	39.5	6	0.03	13.6	8	0.2	50.37	47	0.58
Co. 210	5.0	1	0.5	1.6	5	0.96	26.37	27	0.09
Co. 205	6.7	4	15.00	1.0	4	9.0	0.13	1	0.7
Co. 285	Not grown on a field scale.						5.5	5	0.12

The increase in the percentage of mosaic in Co. 213 in 1932 is due to high infection in three localities in the Siwan Sub-division consisting of 1.76 acres with 12 per cent. infection. The Coimbatore canes have almost completely ousted the local variety in the area examined but in two localities (0.64 acre) the latter was found to be wholly infected with mosaic disease.

Yellowing of canes. The yellowing of canes mentioned in the last year's report appeared again in the Pusa and the Sepaya Farms and also in many other places during July and August but in most places plants recovered later on. The different fungi isolated from the decaying roots proved to be saprophytic. Application of calcium sulphate, potassium sulphate and uspulun had some effect in the recovery of plants from yellowing. The plants responded to potassium sulphate more readily. Further experiments are being conducted by the Imperial Agricultural Bacteriologist.

Top-rot. The species of *Fusarium* causing top-rot has been definitely identified as *Fusarium moniliforme* Shel.; its parasitism has been established, the top-rot and the other typical symptoms have been reproduced artificially. The disease is caused by the infection of the growing point in the early stages of the growth of the cane. In cases where infection takes place late the fungus is kept in check, the plants grow normally, and the effect of the fungus is only seen in the shortening of the leaf

blades especially at the ends of the shoots. The disease was noticed in the following cane varieties at Pusa :—Co. 210, 213, 214, 285, 299, 303, 313, 322, 331, 337, 339, 344, and at Dacca, Co. 213, 223, 281, 361, 364, 386, 403, 407 and 417.

Red-rot. An out-break of red-rot was observed on Co. 210 in the latter part of November 1932 in Pusa and surrounding places. In one place where Co. 213 was growing next to Co. 210 or mixed with Co. 210, Co. 213 was free from the disease, only Co. 210 was found attacked and the infection was up to 40 per cent. In Pusa in Co. 210 the disease had just begun to enter the stem through the buds and as a precautionary measure only the top one-third of the cane was planted and up to the end of June 1933, the disease has not appeared in any of the plots. It is presumed that infection had taken place from spores of *Colletotrichum falcatum* found on the mid-rib of leaves after being washed down by rains to the nodes. This is an interesting occurrence, for the cane at Pusa has been free from red-rot for six years. Several isolations of *Colletotrichum falcatum* have been made from the mid-rib of the leaf and the stem of various varieties of sugarcane grown in different localities in India with a view to determine the number of physiological strains in this species.

H. Sacchari. Dr. Mitra's study of *Helminthosporium* on sugarcane was continued. Three more strains of *Helminthosporium* were isolated, one from Allahabad and two from Arbhavi (Bombay) and are being compared with *H. Sacchari* Butl. from which they differ in cultural characters to some extent but the spore morphology shows that they are closely allied and may only be different strains. The two strains from Arbhavi were isolated from different spots of similar appearance but one was highly sporulating with longer spores as compared to the other. This highly sporulating strain resembles a saltant isolated from *H. sacchari* to a great extent and occurred not only in nature but also appeared as a saltant from a single spore culture of the other Arbhavi strain. The pathogenicity of these three isolates is being tested and preliminary tests show that one is more vigorous than the other. A large number of saltants were grown from generation to generation. Several of these reverted to the parent form, while many bred true and formed sclerotial bodies. A large number of spore measurements are being made for comparison and the pathogenicity of all the saltants is being tested.

(iii) HIBISCUS SABDARIFFA

Stem rot. This disease due to *Sclerotinia sclerotiorum* (Lib.) de Bary again appeared in the first week of January in a more virulent form. Plants sown in a plot highly infested, artificially, with sclerotia and mycelium, did not show the presence of the

fungus until December. When the disease appeared, plants were again examined by Dr. Mundkur and it was observed that the parasite was localised in the upper part of the stem and could not be traced down to the soil. The disease also appeared in plants growing in sterilized soil in pots, and it thus became manifest that the infection was air-borne. The finger-like processes referred to last year developed apothecia both in moist saw dust and in culture media. For apothecial development an air temperature of below 23°C. seemed to be necessary and this occurs in the last week of December and in January. The appearance of the disease in January together with the fact that the parasite develops the ascospore stage only in the cold weather showed that infection is mainly due to these spores. Varieties maturing by the time the disease appears would automatically escape infection and attempts are being made to see if the type under study can be made to set seed a little earlier.

(iv) RICE

Sclerotial diseases. In plots artificially infected by mixing with the surface soil a large number of sclerotia of *Sclerotium oryzae* Catt. paddy plants were transplanted at the proper time. There was a good deal of damage to the crop due to white ants and typical sclerotial disease was not observed. Studies on the large number of cultures of the sclerotial fungi attacking rice have been continued by Dr. Mundkur. It looks as though there are more than one species, that there is physiologic specialization and that there are geographical strains. Careful observations on the manner and mode of growth on nutrient media have been recorded and sclerotial measurements made for statistical examination of data. Sclerotial measurements of parent-progeny have shown, after biometrical examination, that they are reliable guides in the separation of physiologic forms and of species. Using malachite green as a differential dye, it has been found possible also to distinguish species which are otherwise difficult to diagnose.

Sterility. A number of rice plants showing symptoms of sterility were noticed on the Cuttack Farm in scattered patches. An examination of diseased plants showed the presence of some mycelium at the nodes and a species of *Cephalosporium* was isolated. Infection experiments to test the pathogenicity of this fungus are in progress.

(v) PIPER BETEL

The temperature relationship study of six strains of *Phytophthora*, isolated from betel-vine, was made and was compared with five other known species of *Phytophthora*. A series of inoculations and cross-inoculation experiments was carried out and the previous year's observations were confirmed. To control

'foot-rot' caused by *Rhizoctonia solani* and *Sclerotium rolfsii*, Kerol treatment (0.07 per cent.) was repeated and promising results confirming last year's were obtained. Phenyl in 1.0 per cent. and 0.5 per cent. strength was also tried and this gave promising results. No deaths took place in pots infected with *S. rolfsii* or *R. solani* where Kerol or phenyl was applied.

(vi) CROTALARIA JUNCEA

Wilt disease. During last two years a wilt disease of sann-hemp has been noticed to do considerable damage and an estimate made during the year under report showed that in one particular plot the disease was up to twenty-three per cent. *Neocosmospora vasinfecta*, two strains of *Rhizoctonia*, one definitely *R. solani*, and *Fusarium vasinfectum* were isolated by Dr. Mitra. The parasitism of *Fusarium vasinfectum* and the two strains of *Rhizoctonia* was established by infecting sterilized soil with pure cultures and growing disinfected seeds. In a plot heavily infested with last year's wilted sann-hemp plants this crop was grown and all the diseased plants were periodically removed and examined. Out of a total of 280 plants, 193 died of *Fusarium* and twenty-six of *Rhizoctonia*, giving 69.0 and 9.5 per cent. of wilt respectively. It was further observed that the deaths due to *Rhizoctonia* were mostly in the early stages of the growth of the plant and *Fusarium* wilt appeared a little later in the season.

Experiments carried out showed that the *rahar* strain of *Fusarium vasinfectum* can produce wilt in sann-hemp and vice versa, while the cotton strain of *Fusarium vasinfectum* does not infect *rahar* and sann-hemp, nor do the *rahar* and sann-hemp strains infect cotton. In an one-tenth acre plot heavily infested with *rahar Fusarium*, 204 plants of susceptible Dharwar cotton, 215 of susceptible *rahar* and 204 of sann-hemp were sown in alternate rows and at the time of harvest none of the cotton plants had died of wilt, while 72 per cent. *rahar* and 57 per cent. sann-hemp plants wilted. Eight plants of sann-hemp and 76 of *rahar* were grown in pots filled with soil infested with sann-hemp *Fusarium* and 92 per cent. of sann-hemp and 64 per cent. of *rahar* plants wilted. Among 78 plants of *rahar* and 60 plants of sann-hemp grown in soil infested with *rahar Fusarium* in pots the wilt percentage was ninety-two and fifty-three respectively. Forty plants of cotton were grown in pots infested with *rahar Fusarium* and forty in pots infested with sann-hemp *Fusarium* but none took infection.

(vii) CICER ARIETINUM

Mystrosporium sp.—The study of *Mystrosporium* sp. causing bean leaf blight in Pusa was continued. Experiments to control the disease were repeated and the effect of the following fungicides was tested:—Wet seed treatment—formalin and uspultin, dry seed treatment—sulphur and ceresan and spraying of plants with one

per cent. Bordeaux mixture and dusting with colloidal sulphur RV3. Seeds of types 68, 69, 70 and 71 were heavily infected and treated in some plots by wet or dry fungicides and in others sprayed or dusted when the plants came out. The disease did not appear in Types 70 and 71 even in infected plots but was bad in Types 68 and 69, especially in the former. One per cent. Bordeaux mixture sprayed once in three weeks was effective to a certain extent. The treatment will have to be repeated before any conclusion can be drawn.

During the year 60 types of gram were grown in the Botanical Area and four in the Farm on a field scale and in none of these was the disease noticed.

(viii) PHASEOLUS SP. AND OTHER PULSES

A study of species and strains of *Cercospora* on various pulses such as *Phaseolus radiatus*, *P. mungo*, *P. aconitifolius*, *Cyamopsis tetragonoloba*, *Vigna catjang* and *Stizolobium* sp. was started by Udai Bhan Singh with a view to determine whether there are a number of species or merely strains of a single species. Single spore cultures were grown and the morphology studied. All the isolates are being compared under various standard conditions of growth in culture media. During the course of this study a large number of saltants appeared; these have been purified and are being compared with the parent forms. Inoculation and cross-inoculation experiments are in progress to determine the host range of each.

(ix) CANNABIS SATIVA

A species of *Cercospora* was isolated from *Cannabis sativa*. The fungus forms dark brown elongated spots usually on the under-surface of the leaves and in severe cases a number of spots coalesce and destroy almost the whole leaf-area causing curling and drying of leaves. The morphology of the fungus was studied and it appears to be a new species.

(x) JASMINUM ANGUSTIFOLIUM

A species of *Cercospora* was found to do considerable damage to the leaves of *Jasminum angustifolium*. The fungus attacks the under-surface and forms large dark brown spots. In advance stages the whole leaf is destroyed. The fungus appears to kill the leaf tissue in advance as no mycelium has been noticed in the discoloured area outside the central dead portion on which fructification is found. It appears to be an undescribed species. Another *Cercospora* was isolated from *Nyctanthis arbor tristis* and is being compared with the above-mentioned species.

(xi) *Panicum trypheron*

A species of *Sclerospora* was recorded for the first time on this host and a study of its morphology shows that the fungus agrees with *Sclerospora sorghi* West. and Uppal. All attempts to induce the oospores to germinate have failed so far and consequently no infection took place when cross-inoculation was made on maize, jowar and other cereals.

(xii) TOBACCO

Alternaria sp. A comparative study of the two forms of *Alternaria*, one causing stem-rot and the other forming leaf-spot of tobacco, is in progress and infection experiments are being conducted to test their pathogenicity and to determine whether the leaf-form can cause stem-rot and *vice versa*.

Stem-rot. The investigation on the stem-rot disease caused by *Sclerotinia sclerotiorum* (Lib.) de Bary was continued by K. F. Kheswalla. The optimum temperature for its growth was found to lie between 20-25°C. and the maximum at 30°C. beyond which the fungus ceases to grow. Microconidia develop profusely in water culture, agar and on potato agar, and on richer medium it is delayed till the food material is exhausted by the growing sclerotia. Further it was observed that microconidia develop from germinating ascospores on old apotheca. All attempts to induce microconidia to germinate failed so far. Low temperature was found to favour the development of apothecial stalks. Inoculated seedlings and seedlings grown in artificially infected soil took infection and formed sclerotial bodies in the central portion of the stem, thus establishing its parasitism.

(xiii) CINCHONA

Inoculation experiments with *Verticillium* sp. and *Sporotrichum* sp. isolated from diseased cinchona plants were carried out by the Superintendent, Cinchona Plantation, Valparai, and gave successful results.

(xiv) WHEAT

Tilletia indica Mitra. Bunt due to *T. indica* was noted by Dr. Mitra in a virulent form in Karnal on many of the wheat varieties grown at the Botanical Sub-station. Damage was up to 20 per cent. in some cases. Opportunity was taken to make more detailed observations than have been possible so far. It was noted that in a spike only a few spikelets, about 1 to 5, are affected, complete infection of the spikes being absent. In unripe ears it is necessary to break the spikelets to see the diseased grain. In

advanced cases the glumes spread apart and the blackened inner wheat grain protrudes. Careful examination of the tip of the spikelet may sometimes show a black spot which is usually an indication of a diseased grain within. More often a lens is necessary to see the bunt. Because of the abundance of material, it was possible to find out that this bunt has also a distinct fishy smell like *T. tritici*. Germination of the spores has been secured but factors inducing profuse germination are not yet known. This bunt seems to be restricted to the cooler regions of the plains like Karnal and other Punjab districts, while the other two, *T. tritici* and *T. levis*, are restricted to the more cool hilly tracts. Extensive tests with seed treatments, both dry and wet treatment, have been planned for trial next year in order to check the disease, if possible.

H. tritici-repentis Died. on wheat, which forms leaf spots similar to *H. sativum*. was studied in culture. Of the several isolations two strains were common, one of which formed immature perithecia of the *Pyrenophora* type. The fungus does not sporulate in culture but on straw culture a very large number of sclerotial-like bodies appeared which later on formed immature perithecia and on their surface conidiophores appeared and formed conidia. Straw cultures at 20°C. and below formed more conidia but the perithecial bodies remained immature though in rare cases a few asci were noticed.

The percentage of leaf-area destroyed by *Helminthosporium sativum* P. K. and B. and *H. tritici-repentis* Died. was estimated on varieties of wheat grown at Pusa and Karnal respectively. With the exception of a few varieties in which the percentage of leaf area destroyed was up to 6.3, all the varieties and cultures at Karnal were free from the disease. A good deal of variation has been observed at Pusa in the percentage of attack not only from plot to plot but also in the same plot. In the samples examined the range of attack varied considerably, e.g., P. 4 and P. 52 on the farm gave an average leaf destruction of 17.2 and 18.8 per cent. as compared to 6.7 and 2.3 in the Botanical Area.

Wheat rust. A survey of wheat rust on all the varieties of wheat grown in the Botanical Area and Farm at Pusa and on all the varieties grown in the Botanical Sub-station, Karnal, was made as in the previous year. At Pusa, the orange rust appeared as usual during X'mas and was first noticed on the 29th December, 1932. The yellow and black rust appeared rather late during the year and were first observed on the 3rd and 13th February 1933, respectively, as compared with the 16th January and 5th February of last year. As in the previous year, the attack by all the three rusts was mild except in the case of Bihar 121 which was rather heavily attacked with orange rust. Yellow rust was not so severe on P. 52 and P. 115 as last year.

The leaf surface covered by the rust pustule was measured as in the previous year and the average percentage of leaf area affected in various varieties grown in Pusa is given below :—

Variety	Orange rust	Yellow rust	Variety	Orange rust	Yellow rust
P. 4 . . .	0.04	..	P. 114	8.5	..
P. 6 . . .	0.51	0.21	P. 115	..	0.95
P. 12 . . .	2.01	Traces	P. 80.5	0.37	..
P. 52 . . .	0.03	0.18	Federation	..	..
P. 101 . . .	0.01	..	Bihar 121	17.3	2.0
P. 111 . . .	0.01	..	Muzaffarpur	8.0	5.4
P. 112 . . .	9.7	..	Muzaffarnagar	6.2	Traces
P. 113 . . .	8.3	..	8A	10.4	..
Country . .	1.03	0.42			

At Karnal all the varieties were lightly attacked with orange rust. Yellow rust was fairly common on a number of varieties and the attack on P. 52 and P. 115 was as bad as last year. Black rust was absent except on certain Canadian and Japanese wheats of which the latter were badly attacked. At Pusa there is little yellow rust on P. 52 and P. 115, and it is suspected that the Karnal strain of yellow rust is physiologically different from that of Pusa and Dr. K. C. Mehta who is engaged on the study of wheat rusts has very kindly agreed to test this view by conducting a series of infection experiments.

At the request of Dr. K. C. Mehta aeroscopes were again placed in wheat fields and exposed slides were sent to him at regular intervals from the 15th September 1932 to the 15th March 1933. Similar slides were also exposed for the Section at various places including the roof of the Institute building and though a careful microscopic examination was made of these slides no wheat rust spores were observed until after the appearance of rust in the fields.

(20) BARLEY

Dr. Mitra again made an estimate of the percentage of leaf-area destroyed by *Helminthosporium teres* and *H. sativum* on twenty-four types of barley grown in the Botanical Area. The intensity of the disease was found to be less than in the previous year. The percentage of leaf area destroyed by *H. teres* ranged

from 0.27 to 20.45 as compared with 0.5 to 25.4 of last year and that by *H. sativum* from 0.22 to 6.78 as compared with 1.2—14.2. An estimate of the percentage of leaf surface rendered ineffective by these two species of *Helminthosporium* was also made on twenty-six other Indian and foreign types of barley which are being tried at Pusa, and it was noticed that all the seventeen foreign types were free from *H. teres* and the attack by *H. sativum* was mild, the percentage of leaf destruction ranging from 0.1 to 1.85, on the other hand, all the nine Indian types, with the exception of one, were attacked by *H. teres*, the percentage ranging from 0.44 to 11.7, and all except three were free from the attack of *H. sativum*. Cawnpore 251 and Cawnpore 252 were the only types which were attacked by both the species.

The experiment to test the comparative resisting power of twenty-four types of Pusa barley varieties to *Helminthosporium* together with the effect of uspulun as a seed treatment was repeated, and six replications comprising 120 plots were laid down. All the seedlings which died of foot-rot or root-rot were removed twice a week and examined and when the crop was fully grown, the percentage of leaf area destroyed and the yields were estimated. All the figures obtained are being statistically examined. The efficiency of uspulun to control the *Helminthosporium* disease was again confirmed during the year, e.g., T. 21 had an average attack of 0.05 per cent. in plots treated with uspulun, and with untreated seed the average was up to 4.72. That uspulun treatment also checks the attack by smut (*Ustilago hordei*) is illustrated by the following figures. In a plot sown with T. 21 and treated with uspulun, not a single smutted head was found among 6,650 plants, while out of 7,512 plants grown from the same seed but untreated the number of smutted plants was 114, giving 1.5 per cent. of smut.

Rust. Yellow rust, as in wheat, was severe at Karnal as compared with Pusa where the attack was mild on the same varieties of barley, only a few varieties escaped infection at Karnal, and here also a different physiological strain seems to play an active part.

(xvi) CHILLIES

The study of the wilt disease of chillies was continued and the pathogenicity of eight strains of *Fusarium* was tested in pots and in plots on four Pusa Types 34, 41, 46 and 51. Last year infection was found to take place in seedlings grown and infected in test tubes. Fresh isolations were made and the pathogenicity under all conditions was tested in pots, wooden boxes and plots, each plant being infected with a heavy dose of the fungus grown in stock culture, but no results were obtained. The effect of soil

moisture to produce wilt was also tested in sterilized pots in which soil moisture was regulated from 5, 10, 15 and 20 per cent. respectively and the soil was heavily infected but no plant died of wilt.

IV. MISCELLANEOUS

Sclerotium rolszii. Comparative studies on various isolations from different hosts have been continued by Dr. Mundkur. While sclerotial size seems to be constant within a strain, it differs from other isolations in a steady and constant manner. Rates of growth on standard agar in Petri-dishes, with many replicates, differ statistically (using the Analysis of Variance tests) with different cultures. That there is physiological specialization is quite manifest but whether there is parasitic specialization remains to be seen. A Corticium stage appeared once in a culture, but it has not been seen since. Attempts are being made to obtain it.

Fruit tree diseases. A survey of diseases of fruit trees in British Baluchistan was undertaken during the year by K. F. Kheswalla and the following fungi were recorded there for the first time:—Apple—*Coniothecium chomatosporium* Corda. (blister disease), *Alternaria* sp. (apple rot), *Penicillium* sp. (soft-rot or blue mould), *Trichothecium* sp. (Pink rot), Jonathan spot (Physiological), leaf scorch (Physiological also on pear, walnut and apricot). Peach—*Exoascus deformans* Fuckl. (leaf curl), *Cladosporium carpophilum* Thuem. (scab or freckles), Splitting of fruits (Physiological), *Phyllosticta* sp. (shot hole of peach, almond and apricot), *Gummosis* (all stone fruit trees). Grape—*Uncinula necator* (Schw.) Burr., *Oidium* stage (Powdery mildew), *Clasterosporium* sp. (leaf spot). Fig—*Capnodium* sp. (sooty mould). Pomegranate—*Sterigmatocystis castanea* Pott. (internal rot). Water-melon—*Phythium aphanidermatum* (Eds.) Fitz.

Coniothecium chomatosporium Corda. was recorded on apples received from Kulu and *Colletotrichum gloeosporioides* Penz. on mango from Calcutta and also on citrus twigs from Cuttack.

Seedling diseases due to Rhizoctonia. Rhizoctonias isolated from various host plants are also under study but much progress has not however been made. In order to control the seedling diseases due to this fungus seed treatment was tried on chillies and tobacco. Mercury bichloride, uspulun, granosan, germisan were tested and in each case excellent results were recorded, the dust treatment (granosan) giving better result.

Sugarcane transpiration experiments. In order to determine the daily and weekly rate of transpiration of sugarcane experiments on a large scale have been started since last March and interesting data are accumulating. At the same time, in order to know the water content of soil in a typical unirrigated sugarcane field,

weekly determinations of moisture at 1" to 6" and 18" to 24" depths are being made, in such a manner that statistical examination of results would be possible.

Meteorological observations. As the cause, development and spread of many plant diseases are to a great extent controlled by soil and air temperatures, humidity and rainfall, meteorological observations are being carefully made, and data compiled. These data will help to find out why a disease is present or absent during a particular period of the year.

V. SYSTEMATIC WORK

Uromyces cicer-arietini (Grogn.) Jacz. Boy was recorded for the first time from Karnal, Punjab, on *Cicer arietinum* and *Rhizoctonia bataticola* (Taub) Butl. was noted on sugarcane at Pusa. A good deal of assistance was given to the Bihar and Orissa Department of Agriculture, in the investigation of the diseases of sugarcane, potato and other crops, including treatment of five hundred maunds of barley seeds against smut, and to the Bengal Department of Agriculture, in the investigation of the diseases of piper betel, rice and tobacco. A large number of diseased betel-vines were received from Bengal throughout the year for identification. Help was rendered to various workers in mycology and plant pathology in various Departments of Agriculture and Universities in the identification of diseases of cultivated and ornamental plants, supplying cultures and specimens of fungi and other information including methods of control. Specimens were received for identification from the public and the Indian States. Fresh specimens of wheat and barley rusts were supplied on several occasions to Dr. K. C. Mehta of Agra, for his investigation of cereal rusts. The Section usefully served foreign workers by supplying information, cultures and specimens, e.g., to Dr. C. M. Tucker, Missouri (U. S. A.), cultures of five species of *Phytophthora*; to Dr. E. C. Tulis of Arkansas, culture of *Sclerotium oryzae*; to Dr. T. Matsumoto of Formosa, culture of *Hypochnus sasaki* Shirai; to Professor Johanna Westerdijk of Holland, *Fusarium moniliforme* and eleven other sugarcane fungi; cultures of *Sclerotium rolfsii* and *S. oryzae* to Professor Curzi of Rome. Thirty-six specimens of *Cercospora* were received from the Director, Bureau of Science, Manila, P. I., in exchange for an equal number of Indian *Cercosporas*. Eleven specimens from the Professor of Botany, Khalsa College, Amritsar, 160 specimens of miscellaneous fungi from Dr. J. H. Stevenson of Washington and 150 specimens from Dr. H. Sydow of Berlin, were received in exchange.

Acknowledgment is due to Dr. J. J. Taubenhause, Texas (U. S. A.), for identifying cotton root-rot specimens, to Dr. K. Nakata, of Imperial University, Fukuoka, Japan, for supplying cultures of

Sclerotium oryzae sativa and *S. sphaeroides*, to Dr. T. Matsumoto, Formosa, for comparing the Indian strain of *Hypochnus sassaki* on sugarcane, and to Professor Johanna Westerdijk of Holland, for confirming our identification of *Fusarium moniliforme*.

VI. PROGRAMME OF WORK FOR 1933-34

I. RESEARCH WORK

New diseases of Indian crops that come to the notice of the Section will be investigated. Diseases on the following crops will receive special attention :—Sugarcane, wheat, barley, rice, Piper betel, gram, sann-hemp, tobacco, *Hibiscus sabdariffa*, potato and pulses.

The investigations in progress include :—

- (i) Experiments to determine the resistance of Co. varieties of sugarcane to mosaic and tonnage experiments to determine the loss due to mosaic.
- (ii) Experiments to find out suitable remedial measures to check the diseases of Piper betel.
- (iii) A study of the diseases of cereals and sugarcane caused by species of *Helminthosporium* and determination of percentage of rust and *Helminthosporium* on various varieties of wheat and barley.
- (iv) Studies on various sclerotial and other diseases of rice including the wilt disease caused by a species of *Cephalosporium*.
- (v) Stem-rot disease of *Hibiscus sabdariffa* and tobacco caused by *Sclerotinia sclerotiorum*.
- (vi) A comparative study of various strains of *Sclerotium rolfsii* and *Rhizoctonia solani*.
- (vii) Wilt disease of sann-hemp caused by *Fusarium vasinfectum*.
- (viii) A study of the bunt disease of wheat caused by *Tilletia indica* and remedial measures.
- (ix) A comparative study of *Cercospora* on pulses and other crops.
- (x) Sugarcane transpiration experiments and meteorological observations.
- (xi) Fruit tree diseases.

2. TRAINING

Students and assistants will receive training on the lines indicated in the prospectus.

3. ROUTINE WORK

Advice and assistance as required will be given to other departments and the general public.

VII. PUBLICATIONS

- McRae, W., and Subramaniam L. S. Effect of Mosaic on the Tonnage and Juice of Sugarcane in Pusa, Part III, *Ind. Jour. Agri. Sci.*, Vol. III, October 1933, pages 870—880.
- Singh, U. B. Physiology of *Cercospora dolichii* E. & E. *Ind. Jour. Agri. Sci.*, Vol. III, June 1933, pages 496—529.
- McRae, W. & Shaw, F. J. F. . Influence of Manures on Wilt Disease of *Cajanus indicus*. Scientific Monograph No. 7 of the Impl. Council of Agric. Research.

(2) SCHEME FOR RESEARCH ON MOSAIC AND OTHER DISEASES OF SUGARCANE

(Financed by the Imperial Council of Agricultural Research)

I. INTRODUCTION

Though work on the diseases of sugarcane has formed a substantial amount of the activities of the Mycological Section at Pusa, it was limited by the size of the staff available after giving due consideration to the claims of other crops. A five-year scheme providing for the appointment of a Class I officer, a Class II officer, and a Research Assistant and a Fieldman in the subordinate service whose whole time may be devoted to research on mosaic and other diseases of sugarcane was therefore submitted to be financed by the Imperial Council of Agricultural Research as soon as the Council was constituted. The scheme was accepted by the Council in 1930, but, owing to financial stringency which supervened, final orders sanctioning a non-recurring grant of Rs. 12,000 and a recurring grant of Rs. 53,000 to be spread over a period of three years, were not received until the second week of May 1932. The scheme was accordingly started with effect from the 1st June 1932, and Dr. S. V. Desai, Second Assistant Agricultural Bacteriologist of this Institute, was appointed Sugarcane Mycologist, with effect from the 27th June 1932. Mr. S. A. Rafay was appointed Research Assistant from the 17th October 1932, but the post of Assistant Sugarcane Mycologist was not filled until the 23rd June 1933, when Mr. L. S. Subramaniam, an Assistant in the Mycological Section, was appointed.

An intensive study of the mosaic virus has been taken up, and a new line of attack has been developed to find out the nature of the mosaic diseases. The effect of the mosaic disease on the tonnage of sugarcane has been initiated at the Patna and Cawnpore farms and with the equipment and the land available at Pusa substantial addition to the knowledge regarding the mosaic and other diseases of sugarcane is anticipated.

II. MOSAIC DISEASE OF SUGARCANE

DISTRIBUTION

In addition to the localities and varieties reported to be affected with mosaic in previous reports of the Mycological Section, the

Following canes have been observed to have mosaic disease in the localities noted :—

Bihar—Patna (Farm)—Co. 285, 300, 313, 331, Amritsar Ponda and Sialkot Ponda. Mushari (Sugarcane Research Station)*—Hemja, Chynia, Yuba, Maneria, Mungo, Lewari, Ketari, Barnkha, Co. 317 to 320, 325, 326, 330, 332 to 335, 339, 342, 343, 346, 349, 352, 353, 357.

Bengal—Dacca (Farm)—Co. 281 and 320. Mymensingh (Farm)—Co. 213.

Punjab—Gurdaspur, Jallundur and Lyallpur (Farms)†—Co. 203, 213, 281, 300, 301, 312, 318, 343, 344, 346, 347, 349, 350, P. O. J. 2878, Saretha, Katha and Naba.

C. P.‡—Co. 210 and Red Mauritius.

Madras||—Central Farm, Coimbatore—Co. 360, 361, 408, H. M. 320, 332, and 544. Nellikupum—Co. 205.

Bombay—(Padegaon Farm)—H. M. 213 (Java Hebbal).

The Imperial Cattle-breeding Farm at Karnal was free from mosaic disease, but in June 1933 two local varieties in the block allotted to the Sugarcane Sub-station were found to be affected with mosaic, viz., Dhaulu of Batala and Katha, the percentage of attack being 8 and 63 respectively.

ARTIFICIAL TRANSMISSION OF MOSAIC

Season plays an important part in producing the disease by artificial inoculation, the period before the setting in of rains (from April to June) being the most suitable for successful artificial transmission. It is curious that sunshine facilitates the artificial transmission of the disease.

A series of experiments were carried out to find out the optimum conditions for successful artificial inoculation of the mosaic disease. The following four methods of inoculation were tried to find out their efficiency in producing the disease under three atmospheric conditions, viz., humid, shade and sunshine :—

Method A.—Hypodermic needle injection (finest possible needle).

Method B.—Insertion of fragments of mosaic infected tissue into healthy plants.

*Reported by Sugarcane Specialist, Bihar.

†Reported by Associate Professor of Botany, Lyallpur.

‡Reported by Government Mycologist, C. P.

||Reported by Government Mycologist, Madras.

Method C.—Wrapping tightly a sugarcane leaf showing mosaic infection round the spindle of a cane stalk to be inoculated and rapidly pricking with fine pin (insect) through the mosaic leaf and spindle, 15 times.

Method D.—Gentle rubbing over a large leaf surface with a cloth soaked in juice from mosaic plants.

1. Humid condition was created by placing the pots in a shady place which was surrounded by water.
2. Shade condition was maintained by keeping the inoculated pots in such a position that sunlight did not fall directly on the plants throughout the day.
3. Sunlight condition was maintained by putting the inoculated pots in such a position in the open that sunlight fell direct on the plants throughout the day.

Out of these methods, C was found to be the most efficient one for producing the disease in a series of experiments. When this method was used the period of incubation was the shortest and cent. per cent. infection of plants occurred under favourable natural conditions.

Sunlight condition has been found to be favourable in visible transmission of mosaic in a short time in the inoculated plants in contrast with the humid and shade conditions. as tabulated below :—

No. of shoots showing mosaic in different weeks.

Experimental condition	Date of inoculation	Method	No. of shoots inoculated	Incubation period										
				15th to 21st April	22nd to 28th April	29th April to 5th May	6th to 12th May	13th to 19th May	20th to 26th May	27th May to 2nd June	3rd to 9th June	Total N ₂ of infections	Maximum weeks	Minimum weeks
I. Humid	15-4-1933	(a)	2)	..	..	..	1	2	2	1	..	6	7	4
		(b)	21	..	..	..	2	5	3	..	..	17	6	4
		(c)	18	..	..	12	5	1	..	..	..	18	5	3
		(d)	21	..	..	1	4	5	3	2	..	15	7	3
II. Shade		(a)	32	..	..	1	3	2	..	..	..	7	6	3
		(b)	23	..	..	..	..	5	1	..	..	6	6	3
		(c)	19	..	..	7	4	..	..	..	..	11	4	3
		(d)	25	..	..	1	..	1	2	..	..	4	6	3
III. Sunshine		(a)	23	..	7	6	..	1	2	..	..	16	6	2
		(b)	21	..	..	..	3	4	2	..	..	9	6	4
		(c)	22	..	17	4	..	1	..	..	..	22	5	2
		(d)	17	..	..	4	1	1	..	..	..	6	5	3
				SERIES II.										
I. Humid	3-5-1933	(a)	10	10th to 16th May	17th to 23rd May	24th to 30th May	31st May to 6th June							
		(c)	10	2	6	..	5							
		(a)	10	1	1	..	3							
		(d)	10	4	5	..	..					
III. Sunshine		(c)	10	..	3	..	2							

*1 killed by white ants.

CULTIVATION OF MOSAIC VIRUS IN VITRO

Experiments were devised to induce the multiplication of the virus *in vitro*, but so far no conclusive evidence has been adduced. Tissue culture and other methods have failed to give a culture which reproduces the disease. This should not be taken as an evidence of non-multiplication *in vitro* because the sugarcane mosaic virus is very susceptible to ageing and Chamberland candle filtrates have invariably failed in reproducing the disease. The virulence of the virus is destroyed by so many factors that it is advisable to keep the question open.

While carrying on cultivation experiments it was found that the transfers of the mosaic virus in series in alkaline broth induce a capricious pleomorphic growth. The juice of healthy tissues failed to give similar phenomenon. As this phenomenon was observed in repeated series of duplicated experiments, the detailed procedure is given below:—Juice of mosaic infected as well as healthy leaves was obtained by crushing them in a mortar with a small amount of water. The juice was successively filtered through a cloth, a filter paper and a sterile Chamberland filter candle L3 or L5; 0.5 c. c. of the filtrate was inoculated into 10 c. c. of sterile broth having a reaction of pH 7.8. The broth best suited for the purpose had the following composition:—

Peptone	5	grm.	} Broth was adjusted to pH 7.8 and was sterilized at 120°C. for 20 minutes.
Marmite	.	.	.	.	3	grm.
Lithium chloride	.	.	.	.	2.5	grm.
K ₂ HPO ₄	.	.	.	.	0.2	grm.
MgSO ₄	.	.	.	.	0.2	grm.
Sucrose	.	.	.	.	2.0	grm.
H ₂ O	.	.	.	.	1,000	c.c.

The inoculated broth tubes were incubated at 30°—37°C. for three to five days.

No visible growth developed during the incubation of first transfers. The broth was then filtered through sterile Chamberland filter candle and 0.5 c.c. of this filtrate was inoculated into a series of fresh broth tubes, generally in duplicate and triplicate and incubated. After five days' incubation, transfers from these cultures were made into fresh tubes after filtration. One set was set aside for prolonged incubation to see if any growth developed thereby. In this way a series of transfers were carried out both with mosaic and healthy juice. It was observed that after 10 transfers a slight haziness developed in transfers started from the juice of mosaic infected leaves. The broth was spread on nutrient agar and various other stock agar media but no growth could be discerned on the surface. The haziness increased in the next transfer and spreading of the broth on nutrient agar gave very minute colonies on the agar surface. Most of these colonies failed to give growth on transfer and some gave discontinuous growth

with innumerable minute separate colonies. Further cultivations in broth as well as on agar ultimately gave a heavy continuous growth with small clear depressed areas, similar to bacteriophagic plaques.

The biochemical reactions of the organisms were studied. The growth of the organisms in these culture media was meagre, and the characteristics varied unaccountably. Repeated planting and other culture methods failed to separate the culture into organisms with well established different characteristics. The organisms obtained differed in biochemical reactions from those obtained from tomato mosaic but the growth characteristics and other cultural behaviour were found to be similar.

Attempts to produce the mosaic disease by inoculating the cultures and filtrate of the organisms have so far been unsuccessful. Mosaic-free stock of very susceptible varieties is being multiplied as material for inoculation with these cultures. As long as the conditions which adversely affect the virulence of the sugarcane mosaic virus are not understood, the artificial inoculations with material kept *in vitro* are likely to be unsuccessful.

EFFECT OF MOSAIC VIRUS ON ALGAE

The effects of mosaic virus on unicellular chlorophyll bearing organisms were studied. It was observed that the juice of the mosaic-infected leaves filtered through sterile Chamberland filter candle stimulated the growth of a widely distributed unicellular Coccoid alga of the Pleurococcus Order belonging to the genus *Chlorella*. The juice of healthy leaves under similar conditions had no effect on the growth. Only 0.2 c. c. of the filtered juice was added to 10 c. c. of Kleb's solution in which the alga was inoculated. These effects were confirmed in several series of experiments.

EFFECT OF MOSAIC ON CHLOROPHYLL CONTENTS

The estimation of chlorophyll in the mosaic infected and healthy leaves has been taken up. Badly affected mosaic leaves of Co. 213 contained 20 per cent. less chlorophyll than the healthy ones. The comparative distribution of chlorophyll leaf by leaf in Co. 213 is given below :—

1st young-st open leaf	47%	of similar leaf of healthy plant,					
2nd " " "	75%	"	"	"	"	"	"
2nd " " "	84%	"	"	"	"	"	"
4th " " "	95%	"	"	"	"	"	"

TONNAGE EXPERIMENTS IN CO-OPERATION WITH PROVINCIAL DEPARTMENTS OF AGRICULTURE

In order to study the effect of mosaic on the yield and juice of sugarcane under different climatic conditions and under irrigation, two experiments have been started at Patna and Cawnpore Farms in collaboration with the Deputy Director of Agriculture, Patna, and the Plant Pathologist, U. P.

In Patna Farm mosaic-free plots of the tonnage experiment and the adjoining non-experimental plots were found to be affected with smut, the infection varying from 1.2 to 2.1 per cent. Control measures were carried out.

III. RED STRIPE DISEASE OF SUGARCANE

The occurrence of the red stripe disease of sugarcane has been established for the first time in India. Red stripe disease is characterized by two definite types of lesions, (1) that caused by infection of the leaves and (2) that caused by infection of the growing point. Long needle-like red stripes may be formed in any portion of the leaf blade but generally they appear at or near the base of the leaf blade. They are bright red and follow the course of the vessels. They often coalesce and form a broad lesion. As the leaf matures these lesions assume chocolate-brown colour. Lesions on the growing point bring about top-rot conditions. On splitting open fine needle-like red lines could be traced in the unfurled leaves reaching the growing point. The disease is caused by bacterial infection. The causative organism has been isolated. The biochemical reactions differ slightly from those of *Phytomonas rubrilineans* and *Phytomonas rubrisubalbicans*, which are known to cause the red stripe in other sugarcane-growing countries. The organism is usually associated with a species of *Fusarium* in the diseased tissues but inoculations with *Fusarium* alone failed to reproduce the typical red stripe condition. The organism alone is able to induce the red stripe and top-rot but rather slowly. The *Fusarium* alone also produces a kind of top-rot and local lesions are usually produced. These lesions are blotchy and quite distinct in appearance from typical red stripe lesions. Artificial production of red stripe and top-rot condition is induced very quickly by inoculation of the organism and *Fusarium* together.

The disease occurs in young canes before the break of the monsoon, and decreases with the progress of the monsoon. It was observed to occur on the following varieties in different localities :—

Pusa—Co. 210, 213, 214, 299, 303, 304, 312, 313, 315, 316, 321, 322, 331, 333 to 337, 339, 343, 344, 348, 382, 385, 386, 387 397, *Uba* and *Chunne*.

Sepaya—Red stripe—Co. 210, 213, 297 to 301, 303, 312, 313, 318, 320, 321, 322, 326, 329, 331 to 339, 341, 342, 343, 345 to 350, 353, 354, 356, B. S. 7. 10 and P. O. J. 2696.—Red stripe mixed with top rot—Co. 210, 213, 281, 285, 297 to 301, 303, 312, 313, 317, 318, 319, 321, 322, 323 and 325 to 353.

Dacca—Co. 204, 213, 223, 300, 343, 347, 349, 351, 360, 361, 364, 368, 370, 372, 373, 377, 378, 379, 382, 384, 391, 404, 407, 410 to 413, H. M. 544 striped, P. O. J. 2714, 2725, 2727, 2878 and Badila

At Dacca and Sepaya the disease has assumed serious proportions, the incidence being as much as 80 per cent. in some varieties. The disease does not kill the cane outright but the growth is checked and in cases where the top shoot is affected it causes appreciable loss.

IV. SYSTEMATIC WORK

During the year under report, 17 bundles of specimens of diseased sugarcane were received from various Government farms for examination and report. Cultures of red stripe disease organisms were received from the Fibre Expert to the Government of Bengal, Dacca, for comparison with Pusa strains. It was found that one of his strains was similar to the organisms causing the red stripe disease at Pusa and Sepaya. The virulence of the organisms was lost by long cultivation on agar.

V. PROGRAMME OF WORK FOR 1933-34

I. Mosaic disease—

- (1) Survey of the mosaic disease in India.
- (2) Artificial transmission of sugarcane mosaic to hosts other than sugarcane.
- (3) Cultivation of mosaic virus in vitro, identification of the culture obtained from mosaic tissues. Study of the serological reactions of mosaic virus and the organisms obtained from diseased tissues.
- (4) The study of the physiological and histological changes brought about by mosaic disease in sugarcane.
- (5) Effect of various physical and chemical factors on the virulence of the sugarcane mosaic.
- (6) Tonnage experiments to see the effect of mosaic on the yield and juice of canes.
- (7) Varietal test experiments to see the natural spread and resistance of different varieties.

II. The study of the red stripe disease and its control measures.

III. Sugarcane fungus diseases—

- (1) Comparative study of different isolates of *Colletotrichum falcatum* from thick and thin canes, to see if there are physiological strains.
- (2) Study of *Fusarium moniliforme* causing top rot and control measures.
- (3) Isolation of various fungi from different localities and various varieties in order to see whether Indian strains are identical with those in other countries.

REPORT OF THE IMPERIAL ENTOMOLOGIST

(P. V. ISAAC, B.A., D.I.C., M.Sc.)

I. ADMINISTRATION

I held charge of the Section throughout the year in addition to my own duties as Second Entomologist (Dipterist).

Rai Bahadur C. S. Misra, Assistant Entomologist, was on leave from the 13th May 1933 to the end of June 1933.

One new Class II post was sanctioned but has not been filled yet.

II. TRAINING

One post-graduate student from the North-West Frontier Province was admitted for training.

The Professor of Zoology, Agricultural Institute, Allahabad, United Provinces, was under a special course of training in entomology from the 17th October 1932 to the 12th April 1933.

Two post-graduate students from the Aligarh University worked in the laboratory during the months of April and May 1933.

III. INSECT PESTS

SUGARCANE

In Pusa, *Aleurolobus barolensis* Mask. and *Neomaskellia bergii* Sign. appeared in August and reached their maximum activity in the middle of December. *Gryllotalpa africana* Pall. and some Elaterid grubs injured cane seedlings. Larvae of *Myllocerus discolor* Boh. were present in large numbers on roots of cane.

During July to November large numbers of *Pyrilla* spp. were present on sugarcane after which they became fewer. In July, 222 egg-masses were collected from a plot measuring 33.79 acres and the number of egg-masses collected increased in August and subsequent months. The parasitization of the eggs varied from 84.9 per cent. in September to 95 per cent. by the end of October.

In cane planted in February 1932, *Scirpophaga nivella* Fb. heavily oviposited on seedlings in the early months of the year. In July, 878 egg-masses were obtained from an area measuring 58.60 acres and 247 egg-masses from an acreage of 31.08.

As a result of systematic collection of the egg-masses throughout the active period of the vegetative growth of cane the attacks of this top-shoot borer were comparatively less in the cane plots under observation.

Help was given to the Mycological Section throughout the season in keeping the insect pests in check in the mosaic experimental plots. The egg-masses of the top-shoot borer *Scirpophaga nivella* Fb. were collected and destroyed and "dead hearts" and damaged shoots were removed. The plots were treated occasionally with 0.5 per cent. crude oil emulsion against termites. The burrows of rats damaging canes were located and fumigated with calcium cyanide dust.

At the time of harvest during the end of January 1933, the percentage of damage by *Scirpophaga nivella* Fb., stem-borers, *Emmalocera depressella* Swinh., and termites in the tonnage experimental plot was found to be as given in the Report of the Imperial Mycologist (page 136).

From samples taken at random, from the Imperial Agriculturist's plots in the New Area, Pusa, the average loss in weight in mosaic-free Co. 213, caused by the top-shoot borer *Scirpophaga nivella* was found to be 15.4 per cent.

OTHER PESTS

Diacrisia obliqua Wlk. infested meth (*Phaseolus aconitifolius*), til (*Sesamum indicum*), peas, castor, masuri (*Lens esculenta*), linseed, cabbage and cauliflower. It was specially bad in meth and linseed. *Pieris brassicae* Linn. did considerable damage to cabbage. *Athalia proxima* Klug. was abundant on turnips and mustard and was controlled by dusting with calcium cyanide. *Utetheisa pulchella* Linn. was bad on sann-hemp (*Crotalaria juncea*). *Zonabris phalerata* Pall. considerably damaged flowers of vegetables belonging to Fam. Cucurbitaceae. *Agrotis ypsilon* Rott. was checked by poison baits. *Eugnamptus marginatus* Pasc. attacked fresh leaves of mangoes in July and August. *Earias fabia* Stoll. was present in large numbers on *Hibiscus esculentus* and *H. abelmoschus*. There was a heavy attack of *Sylepta derogata* Fb. on cotton. *Bemisia gossypiperda* Misra and Lamba was also present, though in small numbers, on cotton.

The linseed crop of the Botanical Section was attacked by a Cecidomyid fly the pinkish larvae of which were found feeding upon the pollen of the flowers in March 1933. Light trap against adult flies was set up for about two weeks and a fairly good number of flies were killed.

Samples of stored *gur* (raw sugar) from sugarcane and palmyra palms, received from the Assistant Director of Agriculture, Gaya, were found infested by Nitidulid beetles, *Carpophilus obsoletus* Er. and *C. hemipterus* L., and their grubs. To prevent infestation by the beetles and their grubs it was suggested that *gur* should be wrapped in gunny and kept under *bhusi* (bran) or in containers the mouths of which should be securely closed.

Poison baits consisting of sweetened bran mixed with barium carbonate or potassium cyanide and made into a paste, and fumigation with cyanogas were tried against rats reported to be causing damage in paddy fields and stored rice in a godown at Sabour. The bait containing barium carbonate was more successful than the one containing potassium cyanide.

A preliminary survey of the various insect pests that were reported to be causing enormous damage to the fruit trees in the Fruit Experimental Station, Quetta, and other fruit growing areas in Baluchistan was made. The San José scale *Aspidiotus perniciosus* Comstock, the black scale *Iachnus persicae* Choldok, the green scale *Myzus persicae* Sulz. and the beetle *Scolytus rugulosus* Ratz. were found doing considerable damage to trees of almond, apple, pear, peach, plum and quince. The grubs of a Cerambycid beetle were found boring through the stems and branches of peach, apple, almond, cherry and quince.

In the Insectary the life-histories of about eighty insects were studied partly or fully and some of these have been illustrated mainly in black and white to record the results obtained. The local flora was examined throughout the year with a view to find out the presence of insects or their immature stages at different seasons. Young larvae of *Acherontia styx* Westw. were found feeding on leaves of *Jasminum sambac*. Young caterpillars of *Polytela gloriosae* Fb. collected on leaves of *Crinum* sp. on 25th October 1932 became full-grown on 2nd November 1932. A larva pupated on the 10th November 1932. Hibernation in the pupal stage lasted for about seven months, the moth emerging on 4th June 1933.

Some observations on the habits and habitats and the life-histories of the Asilidae of Pusa have been made.

IV. BEES AND LAC

APICULTURE

Advice regarding bee-keeping was given to eighty enquirers. There was a greater demand than during last year for bee hives, queen excluders and the artificial comb foundations for *Apis indica*. These were supplied to correspondents from different parts of India. The use of different appliances employed in bee-keeping was also demonstrated to several visitors.

LAC

The emergence of lac larvae at Pusa took place on 17th October 1932 and on 23rd June 1933. The temperature during the months of May and June 1933 was much lower than what it was last year, and no damage happened to the lac crop by excessive heat.

V. INSECT SURVEY

Collections were sent out for identification to the following specialists and their help is gratefully acknowledged :—

Termites to the Director, Imperial Institute of Entomology, London.

Jassidae to Dr. H. S. Pruthi, Zoological Survey of India, Calcutta.

Chalcididae, Ichneumonidae and Thrips to Dr. T. V. Ramakrishna Ayyar, Coimbatore, Madras.

Earis sp. to Miss A. E. Prout, England.

Aphididae to Mr. R. Takahashi, Japan.

The following collections were received back identified :—

Thrips and Aphids from Dr. T. V. Ramakrishna Ayyar, Government Entomologist, Madras.

Hymenoptera from A. Wetmore, U. S. National Museum, Washington.

Gryllidae from The Imperial Institute of Entomology, London.

Simuliidae from Dr. I. M. Puri, Malaria Survey of India, Kasauli.

Indian insects were supplied to certain correspondents as listed below :—

Some named Diptera of economic importance to the Assistant Entomologist, Lyallpur, Punjab.

Cecidomyiidae to Dr. H. S. Pruthi, Zoological Survey of India, Calcutta.

Muscidae to Prof. W. S. Patton, Liverpool.

Specimens of *Paederus fuscipes* Curt. to the Entomologist to Government, Punjab, Lyallpur.

Some specimens of *Sphaerodema* to Dr. C. J. George, Bombay.

Four show cases of insect specimens of economic interest to the Imperial Economic Botanist for the Botanical Substation at Karnal.

Some named specimens of Indian Trypanidae to Mr. F. A. Perkins, University of Queensland, Australia.

Insect specimens were received for identification from forty-five correspondents in India and they were named as far as possible.

VI. PROGRAMME OF WORK FOR 1933-34

MAJOR

This will follow generally on the lines of work of the current year and will include investigations of crop pests especially those damaging sugarcane and fruit trees, stored grains pests and blood-sucking flies of cattle.

MINOR

Life-histories of insects will be worked out as opportunities offer. New insecticides and control methods will be tested as occasion arises. Systematic work will be carried on with our resources and the help of specialist correspondents. The Catalogue of Indian Insects will be proceeded with. Advice and assistance will be given as far as possible to Provincial Departments and to all enquirers on entomological subjects.

VII. PUBLICATIONS

The following publications prepared by the staff have been issued during the year :—

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| Bhatia, H. L., and Shaffi, M. | . Life-histories of some Indian Syrphidae. (<i>Ind. Jour. Agri. Sc. II</i> , 543-570, Pls. 1-8, December 1932.) |
| Fletcher, T. Bainbrigge | . Life-histories of Indian Microlepidoptera, Second Series: Alucitidae, (Pterophoridae), Tortricina and Gelechiadae. (<i>Sc. Mono. 2 of Imp. Coun. Agri. Res.</i> July 1932.) |
| Isaac, P. V. | . Papers on Indian Tabanidae, IX—The Life-history of <i>Haematopota roralis</i> Fab. (<i>Ind. Jour. Vet. Sc. and Animal Husb.</i> , II, 278-280, Pl. 1, September 1932.) |
| | Notes on <i>Paederus fuscipes</i> Curt., A beetle which causes vesicular dermatitis in Man. (<i>Agri. and Live-stock in India</i> , II, 33-36, Pl. 1, January 1933.) |
| Misra, C. S. | . The Green Peach-Aphis (<i>Myzus persicae</i> Sulz.) and a new Pyralid Mango defoliator (<i>Orthaga mangiferae</i> , n. sp.) (<i>Ind. Jour. Agri. Sc. II</i> , 536-541, Pls. 1-3, October 1932.) |
| Mathur, R. N. | . Notes on the Bionomics of <i>Odontomyia cyanea</i> Brunetti (Diptera: Stratiomyidae) (<i>Ind. Jour. Agri. Sc. III</i> , 369-376, Pls. 2, April 1933.) |

The following papers were submitted for publication :—

- “ The life-history of a common house cockroach, *Periplaneta americana* Linn., ” by Mr. L. N. Nigam.
- “ Biological Control of insect pests and the possibility of utilisation of *Trichogramma minutum* Riley in India for the control of sugarcane borers, ” by Mr. E. S. Narayanan.
- “ The chief insect pests of Sugarcane and methods for their Control, ” by P. V. Isaac and Rai Bahadur C. S. Misra.
- “ The complete life-history of *Tabanus speciosus* Ric., a blood-sucking fly of cattle, ” by P. V. Isaac.
- “ The life-history of *Paederus fuscipes* Curt., a Staphylinid beetle causing ‘ Spider lick ’—a vesicular dermatitis in man, ” by P. V. Isaac.
- “ Lists of Publications on Indian Entomology for the years 1930, 1931 and 1932, ” compiled by T. B. Fletcher and P. V. Isaac.

REPORT OF THE BACTERIOLOGICAL SECTION

(N. V. JOSHI, B.A., M.Sc., L.Ag.)

I. ADMINISTRATION

Mr. Joshi, Assistant Agricultural Bacteriologist, held charge of the Section throughout the year.

Dr. S. V. Desai was appointed, with effect from 1st June 1932, to the newly-created post of Second Assistant Agricultural Bacteriologist and was closely afterwards appointed to the post of Sugar-cane Mycologist.

II. TRAINING

No post-graduate students were admitted during the year.

A Demonstrator in Plant Physiology from the Hindu University, Benares, a post-graduate student of the Imperial Institute of Animal Husbandry and Dairying, and a research student from Bombay worked in the laboratory for short periods and were helped with their investigations.

III. SOIL BACTERIOLOGY

The two series of rotation experiments started three years ago to test the influence of leguminous crops on the conservation of soil nitrogen were continued. As in previous years, the figures for total nitrogen remaining in the soil at the end of two years were less than at the beginning of the experiment in the winter series, but in the *kharif* series they were higher. Taking into consideration the nitrogen removed by the crops, a gain in nitrogen is found in all the plots of both the series. The highest gain calculated in this way is 363 lb. per acre in the *kharif* (summer) series with the mixed crop of maize and *urid* (*P. radiatus*) and 360 lb. in the *rabi* (winter) series with maize and field pea (*Pisum arvense*) grown in rotation.

For a number of years observations on the total nitrogen content of the soil in experimental plots in the pot culture area, as well as in *dhab* (low-lying) area, have shown that there is a seasonal fluctuation in nitrogen of the soil. This natural fluctuation in nitrogen is of importance in the nitrogen fixation observed in field soils, because if the sample of soil be taken in the low nitrogen season, it may show a rapid gain in nitrogen after incubation in the laboratory; while the soil taken in the high nitrogen season

may show a loss in nitrogen when incubated in the laboratory. Therefore unless these natural fluctuations in nitrogen are carefully observed for any soil, it is not possible to get a correct idea of the average nitrogen fixation in the soil.

In order to correlate the observations on the fluctuation of total nitrogen of the soil with the nitrogen fixation taking place in the soil, attempts have been made to find out the nitrogen-fixing organisms that are active in the soil at different periods. For this purpose, in addition to the growth of organisms after inoculation of the soil in nutritive media, direct observations of the organisms active in the soil have been made by inserting clean sterile glass slides in the soil in the field, as well as, in the same soil kept in a beaker and incubated at laboratory temperature; and it has been found that in April, May and June the *Clostridium* species are the predominant type, especially after the rains or when moisture is added to the soil. The organisms of the azotobacter type are present but do not appear to multiply as rapidly as the *Clostridium* species. Incidentally it has been observed that, below the depth of one-fourth to three-fourth inch, hardly any azotobacter cells are present, the organisms found being exclusively of the *Clostridium* species. It appears, therefore, that the importance of the *Clostridium* group of organisms in adding nitrogen to the soil is much greater than that of the azotobacter group, whose claims perhaps are somewhat exaggerated by previous workers on account of its capacity for fixing large amounts of nitrogen in pure culture.

During the course of investigation on the nitrogen content of the soil in the experimental plots, it was observed that in some years at the time of harvesting maize the nitrogen content of the soil was higher than that at the time of sowing. Experiments were, therefore, carried out to see whether the maize root secretes any substance which can stimulate nitrogen fixation in the soil. For this purpose maize plants grown in the field were uprooted after a week's growth and, after washing their roots, were immersed in distilled water contained in a beaker for twenty-four hours after which time the plants were taken out. It was expected that water in the beaker would extract the substance or substances which the maize plant is likely to secrete in the soil to stimulate nitrogen-fixing organisms. It was proposed to see the effect of the addition of the water extract obtained as above and termed "maize root washings" on the nitrogen-fixing organisms. For this purpose the maize root washings after different treatments aiming at the removal of the bacteria associated with maize roots were added to a mixed culture of nitrogen-fixing organisms growing in Ashby's mannite solution, inoculated with soil and it was found that the root washings after passing through Pasteur filter candle as well as after being heated to 100°C. for 30 minutes stimulated nitrogen fixation. It appears, therefore, that in certain years if the season

is favourable maize plants may secrete a greater amount of root secretions in the soil, and there may be a greater accumulation of nitrogen in some seasons as an effect of the stimulation of the nitrogen-fixing organisms by the maize root secretions.

GREEN MANURES

The field experiment started last year to compare the manurial value of sann-hemp with *urid*, and sann-hemp tops applied later in the season so as to secure the stems for getting fibre out of them, was continued, but the treatment of plots was reversed so that an original difference in the fertility of the soil may not influence the results of any particular treatment.

The net profit reported after meeting the cost of production for the years 1931-32 and 1932-33 are as under :—

Treatment	1931-32	1932-33
	Net profit per acre	Net profit per acre
	Rs. a. p.	Rs. a. p.
1. Wheat after maize	3 12 0	22 14 9
2. Wheat manured with <i>urid</i> . .	16 2 0	14 11 2
3. Wheat manured with sann-hemp .	20 8 0	12 2 2
4. Wheat manured with sann-hemp tops and fibre extracted from the stems	41 1 8	9 4 1

It appears that there is some inequality in the fertility of the experimental area as the same plots under treatment "wheat after maize" in 1931-32 were under the fourth treatment in 1932-33 and in both years they have given the lowest economic returns, and hence only after running the experiment continuously for some years can the superiority of any of the treatments be established. The seasonal effect on crops also played a great part in the experiment in 1932-33 and contributed to the large amount of net profit for the maize-wheat rotation. The yield of fibre from sann-hemp has continued to be about 8 maunds per acre but its value has gone down by 25 per cent. in 1932-33. This reduction in price contributed to lower the net profits from treatment No. 4 wheat manured with sann-hemp and fibre extracted from it last year.

A similar experiment on plots of $1/5$ acre and Latin Square layout with five treatments and five replications was carried out on the farm and the results reported as follows :—

	Value of produce minus cost of cultivation
	Rs. a. p.
T ₁ Fallow, wheat	29 2 4
T ₂ <i>Urid</i> green-manured, wheat	22 6 7
T ₃ Soybean green-manured, wheat	23 7 4
T ₄ Senn-hemp green-manured, wheat	35 4 9
T ₅ Senn-hemp tops buried, fibre extracted from stems, wheat	30 8 3

As the experiment will run for some years and is on a statistical basis, no comments need be made at present.

The experiment on growing Mexican sunflower (*Tithonia diversifolia*) with onions and burying the Mexican sunflower for green-manuring was carried out on comparatively poor land this year. The results show that the control plots with onions alone yielded on an average 89 maunds per acre, while the plots with onions and Mexican sunflower yielded 51.6 maunds onions per acre and 230 maunds of sunflower per acre. This quantity of sunflower would suffice to manure one acre of land. It remains to be seen whether yields obtained in subsequent crops would compensate for the loss in onions. Previous year's results on richer land have shown that the loss in onions is more than compensated by the gain in yields of subsequent crops.

NITRIFICATION

The experiment started to find the seasonal effect on the nitrifying flora in soil taken from the field and kept in the laboratory was continued. It was found that in the field there are generally two principal periods of depression of nitrifying flora in May and October or November due to sudden rise and fall in temperature respectively. Other slight variations occur during the rainy season or whenever there is a change in moisture content of the soil. In the laboratory sample the depression of the nitrifying flora occurs in May and January. The depression due to cold occurs later in the laboratory than in the field probably because the change in the temperature in laboratory occurs later. As the moisture content

in the samples kept in the laboratory remains constant no change due to variation of moisture is observed as is found in the field samples in the rainy season.

The examination of samples of soils taken once a month from the permanent manurial experimental plots Nos. 3, 10, 12, 13 and 16 in the Punjab field was continued throughout the year. The samples obtained in January, May and September were found to nitrify ammonium sulphate and cake more quickly (within 4 weeks) than the samples taken in other months which took 6 to 8 weeks to show maximum nitrification.

The bacterial counts as found by plating were highest in farm-yard manure, complete minerals and green-manure plots in August, while the green-manure *plus* superphosphate and the no manure plots showed the highest counts in December and January respectively. Samples of soils taken from these plots in May 1932 before the rains and just after the rains showed that bacterial plate counts in samples taken before the rains were greater than in the samples after the rains, showing that a large number of bacteria are washed down by the rains. The nitrifying power also showed a great decrease after the rains. This is well brought out by calculating the percentage of nitrogen nitrified in Omelianski solution in 8 weeks when the inoculum was in the form of soil extract equivalent to 1 mg. of the soil.

	Per cent. nitrogen converted into nitrates in 8 weeks	
	Samples before rains	Samples after rains
Farmyard manure	85.0	4.0
Complete mineral	70.0	5.0
Green-manure	20.0	4.0
No manure	12.0	10.0
Green-manure <i>plus</i> superphosphate .	20.0	6.0

No such variation was observed in nitrogen-fixing power in the samples taken before the rains and after the rains when inoculated in Ashby's mannite solution. The results obtained lead to the conclusion that probably the rains wash down the nitrifying and ammonifying organisms to lower depths but not the nitrogen-fixing organisms.

In previous years it was found that calcium cyanamide was converted into nitrate when added to many Indian soils after about 12 to 20 weeks, but in seven soils it took more than 20 weeks for the formation of small amounts of nitrates from cyanamide, although ammoniacal nitrogen was found in fairly large amounts

much earlier, *i.e.*, after a short period of incubation for two or three weeks. As the nitrification was completed later in most of these seven soils without resorting to inoculation of nitrifying organisms, it was inferred that the amount of toxic bodies like dicyandiamide formed during the decomposition of cyanamide in these soils could not kill the original nitrifying flora present in the soils. Experiments were, therefore, carried out to find what concentration of dicyandiamide is toxic to nitrifying organisms by addition of varying quantities of pure dicyandiamide to Omelianski solution inoculated with a culture of nitrifying organisms. It was found that a concentration of dicyandiamide equal to 5 and 10 mg. in 100 c. c. solution had practically no effect on the activity of the nitrifying organisms, but a concentration equal to 25 mg. per 100 c. c. retarded and sometimes inhibited the activity of the nitrifiers. Attempts were next made to see whether the extracts of these soils after incubation for two weeks with addition of cyanamide when no nitrates are being formed have a toxic effect on the nitrifying culture in Omelianski solution. It was found that soil extracts equivalent to 25 mg. in 100 c. c. as dicyandiamide (assuming, of course, that the whole of the calcium cyanamide, which had disappeared from the soils, had been converted to dicyandiamide) did not have any toxic effect in the nitrifying cultures. The soil remaining after extraction, however, showed a decided toxic action on the nitrifying flora. It is concluded, therefore, that in these soils either dicyandiamide is not formed or if formed the concentration is not sufficient to be toxic to nitrifying organisms but the calcium cyanamide is converted into some compound, toxic to nitrifiers, which is not water soluble and is retained in the soil. This compound is brought into solution when the soil is treated with dilute hydrochloric acid and can give off ammonia when distilled with magnesia. Attempts are now being made to follow the course of decomposition of cyanamide in these soils by determining dicyandiamide, urea and the insoluble nitrogenous compound formed in the soil. The chemical methods to be used for determining dicyandiamide, cyanamide and urea were standardised for the determination of the small quantities of these compounds formed in the soils after the addition of cyanamide.

Bacterial analysis of soils under irrigation and under dry farming conditions was continued by taking samples at different depths down to 36 inches, and the number of bacteria as observed by plating and the total nitrogen continued to be higher in the irrigated plots than in the unirrigated plots. The nitrifying organisms have become more active since the experiment was started in 1931 but there is not any marked difference in the ammonifying, nitrifying and nitrogen-fixing power of the soil between the irrigated and unirrigated samples. The change in these activities is comparatively slower than in the total number of bacteria and the total nitrogen in the soil.

THE AZOTOBACTER SOIL PLAQUE TEST FOR DETERMINING FERTILIZER REQUIREMENTS OF SOILS

It is well known that the bacterial activity in the soils depends on the presence of sufficient nutrient materials and other favourable conditions. Advantage is taken of this fact in devising bacteriological methods for examining the deficiencies of soils. One of the group of organisms chosen for the purpose is the azotobacter group of nitrogen fixing organisms, which is very sensitive to acidity and lack of available phosphate in the soil. The method devised by Christensen and Niklewski consisted in finding the lime and phosphate requirements of soils by inoculating the soil to be examined in mannite solution and noting the azotobacter growth. These conditions of growth were considered unnatural by Winogradsky who has developed a method termed *la methode des "Plaques moulees"* or the kneaded soil plate method for directly examining the azotobacter in the soil itself. This method has been modified by other investigators and it has been claimed that it can be applied to detect the potash and phosphoric acid requirements of a soil in a very short time.

The technique consists in adding 5 per cent. starch to the soil and dividing it into 4 lots. No. 1 serves as control. To No. 2 is added 2.5 c. c. of a 3 per cent. solution of potassium sulphate, to No. 3 is added 2.5 c. c. of a 6 per cent. solution of Na_2HPO_4 and to No. 4 is added 2.5 c. c. of a 3 per cent. solution of K_2HPO_4 . These amounts of the salts to be added have been reported to be the optimum to produce good results. The requisite amount of water is separately added to each lot to form a paste which is well kneaded. On a moistened glass plate, the kneaded soil plaques are placed one by one and pressed by the hand to form cakes which are then transferred to a petri dish kept in a moist chamber and incubated for three days at 30°C . Moist glistening colonies of azotobacter make their appearance on the surface of those cakes which supply the requisite nutrients. When a good growth occurs on all the cakes the inference is that the original soil contains sufficient amounts of potash and phosphoric acid. If growth occurs only on the second and fourth cake the inference is that the soil is lacking in potash. If it occurs on the Na_2HPO_4 and K_2HPO_4 cakes, then the soil is deficient in phosphoric acid, while if the growth occurs only on the K_2HPO_4 cake then the soil is deficient in both potash and phosphoric acid.

In case the soil is acid with a pH index 6.5 or less lime will have to be added to neutralize acidity and in some cases where the soil is lacking in azotobacter cells a culture of the organism will have to be inoculated into the soil.

Eight Indian soils of varying pH and physical texture were subjected to this test to find out whether any definite indications

are obtained about their deficiencies of potash and phosphoric acid. The results are given in the following table:—

	Gujrat wala	Pusa no manure	Kallanpur	Sialkot	Krishnagar	Chinsurah	Ranchi	Dacca
pH . . .	8.1	7.3	7.3	7.3	7.3	7.2	6.0	5.9
Control .	O	O	O	OF	+F	OI	O	O
K ₂ SO ₄ . .	O	O	OF	OF	O	O	O	O
Na ₂ HPO ₄ . .	+++P	+	++	++++P	++	++++P	O	OA
K ₂ HPO ₄ . .	+++	+++P	++++P	++++P	+++P	+++P	O	AO

O = No azotobacter

+ = slight growth of azotobacter

++ = Moderate growth of azotobacter

+++ = Fair amount of growth of azotobacter

++++ = Numerous colonies

P = Black pigmentation

F = Fungus growth

A = Actinomyces

From the above it is seen that none of the soils tested except Krishnagar show the growth of azotobacter in the kneaded cakes without treatment (control). The addition of K₂SO₄ does not improve matters in any case. The response to K₂HPO₄ is clearly indicated in all soils except Dacca and Ranchi which are acidic. The response to Na₂HPO₄ is less marked than that of K₂HPO₄ although none of the soils show potash deficiency by responding to an addition of K₂SO₄. The conclusion, to be drawn from these results, according to the originators of the method, is that all the soils examined are lacking in phosphate. We must not, however, lose sight of the fact that there is also the possibility of the test not being sensitive enough to distinguish between the varying degrees of phosphate requirements of the different soils. Further trials were therefore done with soils taken from the permanent manurial plots in the Punjab field experimental area at Pusa. These plots have been receiving the same manures continuously

for the last 20 years or more and should show good growth of azotobacter in soils manured with superphosphate. In this experiment only one treatment with the addition of K_2HPO_4 was tried.

	No manure	Farman manure	Green manure	Complete minerals	Potassium Sulphate	Superphosphate	$(NH_4)_2SO_4$	Green manure and super
Control.	0	+	0	+	0	+	0	0
K_2HPO_4	++++	++++P	++++P	++++P	++++P	++++P	++++P	++++P

Here again a more vigorous growth of azotobacter with the addition of K_2HPO_4 than in the control cakes is seen in all the soils including the soil from the plot treated with superphosphate for 20 years showing that even with this treatment the phosphate in the soil is not readily available for azotobacter.

The marked effect of potassium phosphate on azotobacter led to the suggestion that it may be possible by the use of this method to distinguish between the availability of phosphates of the different phosphatic fertilizers when added to any particular soil. So the following phosphatic fertilizers—(1) Superphosphate, (2) Trichy nodule, (3) Bonemeal solubilized by sulphur-oxidising bacteria in a compost, (4) Bone dust prepared by treating bones with alkali, (5) Powdered apatite called Kudada phosphate, (6) Calcium phosphate (Merck)—were added to four different soils to see the effect of these fertilizers on azotobacter growth. 0.3 grm. of each of the fertilizers was added to the plaques of different soils which were then incubated for three days at 30°C. The results are given in the following table:—

Fertilizer	Pusa soil	Chinsurah	Sialkot	Ranchi
Superphosphate	OF	++F	++F	OF
Trichy nodule	++	++F	++P	0
Solubilized bonemeal	++P	++F	++P	0
Bone dust fine	++*	*++F	*++P	0
Kudada phosphate	0	OF	0	0
Calcium phosphate (Merck)	++P	+-P	++P	0

*—Appearing slowly

Superphosphate is the usual phosphatic manure used and is considered the most easily available to the crops. As used here, it shows the peculiar characteristic of giving a growth of fungi in all the soils but azotobacter colonies only in two. This behaviour may probably explain the encouragement of fungal attacks of crops on the addition of superphosphate to some soils and incidentally also the fixation of the soluble phosphate in an insoluble form into mycelium of the fungi growing in the soil to which superphosphate has been added. The apatite "Kudada phosphate" does not appear to be available to azotobacter in any of the soils. All the other phosphatic fertilizers appear to be more or less available in three soils. In Ranchi soil, none of the substances gives a growth of azotobacter. This is what is to be expected as it is an acid soil with a pH index 6.0. Incidentally it may be pointed out that though originally not intended for finding the lime requirements of an acid soil, this method can furnish the information if cakes of the soil with 5 per cent. starch + 0.3 per cent. K_2HPO_4 are made with varying amounts of lime and the growth of azotobacter noted on them. The cakes after exact neutralization and further additions of lime would show azotobacter colonies and thus give an idea about the probable lime requirements of an acid soil.

PHOSPHATE SOLUBILIZATION

A sample of apatite called Kudada phosphate was composted with green manure, sulphur and charcoal to see whether the insoluble phosphate contained in it could be made available to the crops. The composts made did not show any great increase in soluble phosphate. This is ascribed to the large amounts of iron oxides contained in it, as even treatment with strong sulphuric acid failed to make more than 11 per cent. of the total insoluble phosphate citrate-soluble. Pot and field experiments with the Kudada phosphate by itself and the acid treated Kudada phosphate have shown that although wheat is not benefited by the application of these, other crops like *Eleusine coracana* and mustard give an increased yield with the application of the treated and the untreated apatite. The tentative conclusions are that too much reliance cannot be placed on the chemical analysis of the phosphates, that certain crops are able to extract their phosphoric acid requirements from comparatively insoluble salts and that the presence of SO_4 ions helps to make the insoluble phosphates available to the crops. Composting the apatite with sulphur and green manures is likely to solve the problem of utilization of this apatite. Large-scale field experiments are necessary to place these conclusions on a firmer basis.

IV. BACTERIOPHAGY

The bacteriolytic principle capable of dissolving the suspension of root nodule organisms isolated from berseem root nodules was

tested for the number of types of bacteriophage present in it by the method used by Dr. Asheshov, and it was found that there is only one type of bacteriophage. After establishing the single type of bacteriophage, it was tried on cultures of nodule organisms from *Lathyrus odoratus*, which were found to be susceptible to its action showing that the bacteriophage of the berseem nodule organisms can act on cultures of some other nodule organisms also.

Dissociation. One of the characteristics of the colonies of a culture of the organism *B. cereus* is that it shows pellucid dots resembling plaques caused by a bacteriolytic principle. As the attempts to separate the bacteriophage from the culture of organisms were not successful, it was suggested that the plaque-like appearance may be caused by the dissociation of the organism into different types. A liquid culture of *B. cereus* which is a spore-former was therefore purified by heating the culture to 100°C. in a steamer so as to kill the vegetative forms. From the spores remaining in broth, a fresh culture was obtained by inoculation into a broth tube which was again subjected to a temperature of 100°C. to get a fresh culture from the spores. After repeating this process ten times, a culture was finally obtained which was successively inoculated and passed through series of broth tubes of increasing alkalinity and acidity to observe whether it dissociated into different types, adapted to different hydrogen-ion concentrations. The culture was also transferred through successive broth tubes containing 0.25 per cent. lithium chloride to enforce dissociation more quickly as was attempted by Hadley and others. From both the series of broth cultures when plated, after a series of transfers, two forms could be obtained, a yellow short rod and another white coccil rod, the latter being obtained more frequently than the former. It appears, therefore, that the pellucid dots observed in the cultures of *B. cereus* are the result of the dissociation of the cultures into two types. The cultural characteristics of these two types were tested and found to be different from those of the culture of *B. cereus*. The culture of *B. cereus* used in our experiments was first isolated from the tomato plants affected with mosaic and from the soil in which the mosaic plants were growing. Afterwards *B. cereus* was also isolated from Krishnagar soil in which tobacco plants affected with mosaic were growing.

Filterable forms of bacteria. It was found on many occasions that secondary growths occurred in the filtrates of liquid media cultures of the root nodule organism and *B. cereus* after passing the cultures through L₂ filter candles. The secondary cultures obtained were not due to contaminations from outside organisms but in both cases proved to be the cultures of the original organism filtered. The candles were tested by the air pressure method and were found to be bacteria proof. It was inferred, therefore, that the secondary growths were due to filterable forms of cultures passing through the candle. By filtering the cultures of different ages (from 1 day

old to 1 week old cultures) it was found that filterable forms which give secondary growths in the filtrates are present in the first three or four days. After that time the filterable forms become stabilised and secondary growths or reversion to visible forms in the filtrates of a week's old culture is very rare. By using the technique employed by Hauduroy to get a visible growth from the filterable forms, however, it has been possible to make the stable filterable forms in the filtrates of old cultures revert to visible forms after 4 or 5 transfers of the filtrate on solid agar media. These observations on the filterable stage of two soil bacteria are of importance and have a direct bearing on the study of number and activity of organisms present in the soil.

V. DAIRY BACTERIOLOGY.

The average plate counts of the bacterial content of milk supply are given below with those of the previous two years for comparison :—

Months	Average counts per c. c.			Days present in 1/100 c. c.	Coli counts 1932-33	
	1930-31	1931-32	1932-33		Days absent in 1/100 c. c.	Days present in 1/10 c. c.
July 1932 . . .	5,500	3,833	5,225	4	8	12
August . . .	4,400	4,092	7,857	4	11	10
September . . .	6,700	4,753	10,575	6	6	10
October . . .	2,840	2,333	13,760	2	4	4
November . . .	5,400	3,490	7,713	6	9	6
December . . .	1,840	3,400	4,098	4	5	4
January 1933 . . .	2,200	8,825	6,508	12	0	12
February . . .	2,900	4,000	3,617	9	4	13
March . . .	3,565	9,750	5,071	2	12	9
April . . .	3,472	8,617	3,717	1	11	3
May . . .	3,900	5,871	5,127	3	12	10
June . . .	2,664	7,192	8,283	2	10	9

The counts of the year were higher than those of the previous years for the first five months and the last month but for the remaining six months they were lower despite no change in hours of milking and milk distribution. The probable explanation of this rise in bacterial counts in the same season in alternate years is that the milk of certain individual cows whose lactation period occurs in alternate years has a high bacterial count and therefore leads to higher average counts.

B. coli were found on more occasions than in the former years and were present in high numbers in the cold season especially January and February 1933. Attempts were made to locate the source of these unusually high counts in the cold season. The churns and buckets were free from *B. coli* but the funnel and the pipe through which the milk is passed to the weighing room were found to be the source of this contamination. When examined separately the funnel was also free and only the pipe was involved. Treatment of the tube with catadyn water proved effective but *B. coli* reappeared after two days. Even after sterilization in the autoclave *B. coli* again appeared after a short interval of two or three days. The method of washing the pipe with sodium carbonate was suspected to be not quite effective at the lower temperatures in the cold season, a microscopic film of milk with *B. coli* developing in it being probably retained on the inside of the pipe. A second washing of the pipe at the time of steaming was, therefore, suggested and proved effective. From March the coli counts went down.

A comparison made between Erb's and Newman's stains for smears of milk used in counting the numbers of bacteria by direct examination under the microscope showed the latter stain to be superior, as it gave a more highly stained background with the organisms more distinctly visible than the former could give. Also there was neither precipitate nor fat globules to be seen in the smear with Newman's stain which has the following composition :—

Certified methylene blue	1.0—1.2 grm.
Absolute methyl alcohol (ethyl alcohol 95 per cent. may also be used)	54 c. c.
Technical tetrachlorethane	54 c. c.
Glacial acetic acid	6 c. c.

STARTERS FOR BUTTER MAKING

While studying the lactic acid organisms present in *dahi*, it was observed that none of these develop a pleasant aroma in the butter made by using cultures of the *dahi* lactic acid bacteria for ripening the cream. A number of strains of lactic acid organisms were isolated from dairy milk and commercial butters

under different conditions of storage and were tested for their ability to produce volatile acid in milk and in milk plus citric acid. Only one strain has so far been isolated which produces volatile acid equivalent to 24·7 c. c. of N/10 alkali from 1000 c. c. distillate obtained from 250 c. c. of milk without addition of citric acid and volatile acid equivalent to 43·9 c. c. of N/10 alkali with addition of citric acid. Hammer from one of his satisfactory cultures of aroma producers in butter has obtained the following figures, 23·5 c. c. without citric acid and 63·5 c. c. with citric acid. This strain of organism isolated appears to be similar to *Streptococcus citrovorus* or *paracitrovorus* of Hammer or *Betacoccus cremoris* of Orla Jensen but all these latter organisms studied by Hammer and Orla Jensen do not coagulate milk at 20°C. while the Pusa strain is found to coagulate milk at 20°C. As this characteristic may prove to be an advantage in the use of the Pusa strain, because a single culture of this strain may be useful in ripening the cream by production of aroma combined with sufficient acidity, three large-scale experiments on cream ripening with this aroma-producing organism and other lactic acid organisms were carried out at the Bangalore Institute of Dairying and Animal Husbandry and the butter manufactured was submitted for examination of flavour to the Imperial Dairy Expert. Among the single organisms tried, the aroma-producer isolated at Pusa was easily placed first for making butter for table use in all the three tests, while compared with the cultures of mixed organisms as against the Pusa strain used singly, it stood second to a mixture of the Pusa strain with another strain of the *Streptococcus citrovorus* and *paracitrovorus* group of organisms. For keeping quality or commercial use a triple mixture of this organism and another strain of the *citrovorus* group with the *Streptococcus lactis* was found to be better, because this mixture develops flavour combined with acidity sufficient to keep the butter from deteriorating during storage.

VI. SILAGE

Recently Dr Virtanen has devised a technique by which he claims preservation of grass in the form of silage without fermentation and with an insignificant loss. The attainment of the correct pH value by the addition of some acid is the essential feature of the method. A patented acid mixture is used in such quantity that it increases the original hydrogen-ion concentration of the fodder to pH index 4. A preliminary experiment was made to find out the quantity of hydrochloric acid which when mixed with berseem will bring the mixture to the pH index 4. The acid required was found to be 1 per cent. This quantity was considered to be uneconomical for ensiling berseem. Attempts were, therefore, made to see whether berseem could be preserved with lower concentrations

of hydrochloric acid. Quantities varying from 0.1 per cent. to 1 per cent. of hydrochloric acid were added to berseem in different jars and the nature of the silage, its pH index and palatability to cattle were tested. The different silages obtained were well preserved with all the treatments but those with 0.4 per cent. and higher amounts of acid were not touched by cattle, while those in which 0.1 per cent. to 0.3 per cent. acid was added were much relished.

A pit was filled with berseem by the Imperial Agriculturist to see the effect of the addition of 0.1 per cent. hydrochloric acid, the least amount found suitable in the laboratory. After two months the pit was opened and the silage fed to cattle. Twenty seers was given to each animal, and it was eaten readily. No bad symptoms were observed after feeding in any of the animals. The pH of the pit silage was 5.4, the same as that for the laboratory silage with the same concentration of acid, and the total acidity was 6.0 per cent. on the dry basis.

USE OF MOLASSES IN SILAGE

Attempts were made to see whether molasses could be used for mixing with green fodder for turning it into silage. As the chief advantage of the addition of molasses lies in supplying soluble carbohydrates and in increasing the acidity by stimulating the activity of lactic acid organisms, it was considered advisable to use such fodders as do not develop much acidity when used by themselves, so that fodders unsuitable for silage by themselves could be utilized. Berseem, kudzu (*Pueraria thunbergiana*), *dub* (*Cynodon dactylon*) grass and a mixture of different grasses from the lawn, all of which had not previously given good silage by themselves, were, therefore, selected for turning into silage with the addition of molasses and wheat straw and pH and the total acidity on dry basis were determined at intervals. Acidity was found to develop more quickly after the addition of molasses in all the fodders. The highest amount of molasses added was 10 per cent. of the fodder to be ensiled and developed an acidity of about 17 per cent. on a dry basis. The silage had a pleasant odour, none of the fodder material ensiled by themselves showed any increase in acidity, berseem silage being distinctly alkaline. The silages made from berseem and the mixture of lawn grasses without the addition of molasses or wheat straw, developed a bad odour, while the *dub* grass and the kudzu silages had not a particularly bad odour but neither it could be described as fine. The results of these experiments show that a great advantage would result from the addition of about 10 per cent. molasses to some fodders at the time of ensiling them, and this work will be continued.

VII. POTATO STORAGE

In the storage experiments, country potatoes were not much damaged whether stored with or without charcoal and there was only a slight advantage in favour of storage in charcoal. Country potatoes grown after application of different manures were stored in March 1932 to see the effect of manuring on the keeping quality of potatoes. The potatoes were stored with and without charcoal in all cases. There was a slight difference in favour of charcoal but as only 8 per cent. is the maximum damage due to rotting in storage, no distinction could be made between the effects of different manures.

Hill potatoes were grown under irrigation and stored with and without charcoal with the following results :—

	Non-irrigated		Irrigated	
	Without charcoal	With charcoal	Without charcoal	With charcoal
Per cent. sound tubers recovered .	5.2	53.0	28.1	84.2

It appears that hill potatoes are more liable to damage under storage conditions in the plains. Storage in charcoal helps to prevent 45—55 per cent. damage. Irrigated potatoes keep better in storage than the unirrigated ones. This is due probably to the fact that a greater number of the tubers in the irrigated crop are comparatively more immature than in the unirrigated crop and immature tubers keep better than the mature ones, as it has already been observed in our previous experiments that the crop harvested earlier, and so consisting of more immature tubers, is better able to withstand storage conditions than the crop harvested later.

VIII. PLANT DISEASES

Cauliflower crown rot. Three kinds of bacteria were isolated from the rotting crowns of cauliflower and inoculations were carried out with the cultures. One culture which produced the typical symptoms on inoculations was studied further and was identified as *Bacterium campestris* (E. F. Smith).

Leaf stripe of juar. A disease of *juar* (sorghum) received from the Millet Specialist, Coimbatore, was identified as the leaf stripe disease of sorghum caused by *Bacterium andropogoni*.

Wheat ear cockle. Diseased wheat ears received from the Agriculturist at Sakrand farm, Sind, contained numerous bacteria in the grain of the ears, although no nematodes were found to emerge from the ear cockle galls. The disease appears to be similar to the ear cockle caused by *Bact. tritici*, gaining entrance after the attack by the nematodes.

Tobacco disease from Krishnagar.—Healthy and diseased specimens of tobacco plants from the same field were received from Krishnagar farm. Three kinds of bacteria were isolated from the diseased specimens but none of them resembled *B. solanacearum*. The soil surrounding the roots of the diseased and healthy plants was plated and gave a number of bacteria among which was observed *B. cereus*. As this organism in the soil has been found to be associated with tomato mosaic, it was suspected that the wilting might be due to tobacco mosaic. Inoculations were, therefore, made from diseased leaf tissues. Some of the plants inoculated with leaf tissues showed distinct signs of mosaic after five or six days.

Yellowing of canes. A peculiar yellowing of canes in the Saran District appeared after the heavy rains in July 1931 and 1932. The leaves turned yellow from tip downwards and later reddish streaks and spots made their appearance on the leaves. Generally the fourth or fifth leaf from the top first showed signs of turning yellow. Yellowing sometimes appeared in the third leaf from the top. Healthy and diseased canes appeared in the same clump. The disease could not be definitely associated with any insect, fungus or bacterial attack. Examination of the roots of diseased and healthy canes showed that in the healthy canes a fresh flush of roots was thrown out regularly from upper nodes when the old ones had begun to weaken and die, but in the yellowing canes there was a scarcity of new roots at the upper internode, showing that the yellowing canes had received some check in its growth. To trace the cause of this check in growth, the soil round the diseased and healthy clumps from several places was collected and examined for nitrates, ammonia and alkali salts but no appreciable difference could be detected. Analyses of leaves from diseased and healthy clumps from different patches of yellowing clumps showed that the diseased yellowing leaves were comparatively poorer in almost all the plant foods. There was more starch accumulated in diseased leaves than in healthy leaves. An examination of the extract of leaves for enzyme activity showed that the yellowing leaves had equal or sometimes greater enzyme activity in hydrolysing starch than the healthy leaf extract, but somehow it was unable to hydrolyse the starch in its own extract. It may be suggested that probably a lack of some substance in the extract of leaves from yellowing canes prevented hydrolysis. This substance could be provided by properly manuring the yellowing clumps, so some

experiments were made on manuring the yellowing clumps with potassium sulphate, gypsum, ferrous sulphate, magnesium chloride and ammonium sulphate, and it was found that clumps manured with either potassium sulphate or ammonium sulphate to a certain extent revived and assumed a healthy appearance.

Water culture experiments showed that the variety Co. 213 which is the one greatly affected is likely to show yellowing in the absence of potassium or nitrogen.

It is concluded from these different experiments that yellowing of canes is a deficiency disease caused by the absence of sufficient amount either of potassium or nitrogen in the soil. A scheme of experiments has been drawn up to decide this point, but as a practicable measure it may be suggested that an extra dose of organic manure like oil-cake containing all the plant foods may be applied to the canes at the time of earthing up on the basis of 50 lb. of nitrogen per acre to such fields as have shown yellowing in past years, and also to those which are showing signs of yellowing for the first time.

IX. PROGRAMME OF WORK FOR 1933-34

Conservation of nitrogen in soil. Conservation of nitrogen is one of the important problems in maintaining the fertility of Indian soils. A series of experiments of growing leguminous crops in mixtures or rotation were started three years back : one adapted to the *khari* season and the other to the *rabi* season. These will be continued and the variations in total nitrogen in the soil and the economic returns of crop will be examined.

Green-manuring. The large-scale experiment will be continued of comparing *urid* and soybean and the application of sann-hemp tops late in the season after removing the stems for fibre, with the usual method of ploughing in sann-hemp. The experiment with Mexican sunflower will be repeated and a large-scale experiment tried on the farm.

Biological analysis of soils. Biological analysis of the samples of soil from irrigated and unirrigated fields will be continued to find what changes irrigation produces. Biological analyses of other soils will be carried out as occasion arises.

Calcium cyanamide. The decomposition products of calcium cyanamide in different soils which nitrify calcium cyanamide much later than in other soils will be studied.

Bacteriophage. Search for the bacteriophage from roots of cereals will be continued and they will be studied after their isolation to find what effect they have on the leguminous nodule organisms in soils.

Dairy bacteriology. Quantitative study of bacteria present in general milk supply at Pusa at the time of distribution and in individual cows with a view to bacterial control of cleanliness in production of milk in the dairy will be continued. Study of starters producing flavour in butter will be continued. Observations on the kind of coli present in milk supply will be made.

Bacteriology of silage. Preparation and study of silage from different fodders with the addition of wheat *bhusa* and molasses will be continued. Study of treatment of fodders with hydrochloric acid for their preservation as in A. I. V. process will be continued.

Other investigations. Study of the preservation of fruits and vegetables by cold storage and the effect of spices in pickles in preventing spoilage will be carried on.

X. PUBLICATIONS

Desai, S. V. The influence of Green Manure and Organic Residues on Nitrogen fixation in Soil. *Ind. Jour. Agri. Sc.*, Vol. III, Part II, April 1933.

———Studies on the Nature of the Causative Agent of the Mosaic Disease of Tomatoes. *Ind. Jour. Agri. Sc.*, Vol. III, Part IV, August 1933.

REPORT OF THE IMPERIAL DAIRY EXPERT

[ZAL R. KOTHAVALA, B.Ag., B.Sc. (AGRI.), N.D.D.]

I. INTRODUCTION

I held the post of the Imperial Dairy Expert throughout the year.

Due to the acute financial crisis which had arisen before the beginning of the year under review it was found necessary to reorganize the working of the farms under the control of the Imperial Dairy Expert with a view to effect reduction in the budget demands of this Section. Some of the salient features of the reorganization were that the commercial activity of the dairy farm at Bangalore was curtailed, experiments in cross-breeding with European cattle to establish a cross-bred herd were abandoned and attention was concentrated on the breeding of high yielding strains of indigenous breeds, while the Wellington farm was maintained solely as a milk producing depot, cows in milk being supplied from Bangalore as required and returned when dry. The total strength of the herd at the Imperial Cattle Breeding Farm, Karnal, was reduced to 400 head of cattle and the 'home cultivation' at this farm was reduced to a minimum, the remaining land being let out on cash rental and *batai* systems to reduce the cultivation expenses to the minimum possible.

All the three farms at Bangalore, Wellington and Karnal were maintained mainly on the same lines as in the past, i.e., as quasi-commercial concerns with education and scientific investigations as their primary functions. The commercial activities of the farms for the year yielded a profit of Rs. 40,509 against a loss of Rs. 11,478 last year. The financial position of the farms had never been so favourable before. Various factors contributed in bringing about such a favourable result but the biggest contribution came from the farm staff who worked whole-heartedly to cope with a difficult situation.

In spite of the adverse financial conditions prevailing throughout the country, the demands made on this office for technical advice and instruction connected with the dairy industry from all parts of India from the general public, associations, municipalities and Provincial Governments were on the increase. This advisory work and the training constitute two of the most important and indispensable portions of the activities of this Section for the advancement of the dairy industry in India. Several requests were received for help for educational and propaganda work on dairy matters from Health Week Committees, Baby Shows, Agriculture and Dairy

Exhibitions, etc., which indicate that there exists an immediate necessity for active propaganda in favour of known methods of improvement in all phases of the dairy and dairy products industry and in animal husbandry in India. The interest evinced by the public in these matters is also indicated by the large number of interested persons who visited the Bangalore Dairy Institute during the year.

The Dairy Institute received a gift from Messrs. Edw. Keventer, Aligarh, of a complete plant of an Alfa Laval Magneto Milking Machine presented by the famous Alfa Laval Co., of Copenhagen, for instructional purposes.

The year proved favourable from the point of view of weather conditions as all the farms reported good and timely rains and although the acreage under cultivation remained the same, increased yields of crops were obtained. Better value was also realized by the sale of farm produce at Karnal due to the market rates remaining favourable. The contrary was the case with the disposal of dairy produce at all the farms.

The condition of the cattle at all the farms remained very satisfactory, there were fewer outbreaks of diseases and the farm at Wellington was particularly free from it. The Karnal farm continued to maintain the two herds of the Haryana and Tharparkar breeds, and with systematic selective breeding it has now been possible to attain a record of over 8,000 lb. of milk per lactation. The record for fat so far obtained is as high as 7.8 per cent. At the Bangalore farm the herd of Red Scindis is gradually being built up and a new foundation herd of the Gir breed was started this year. The policy followed in breeding these two herds is on pure line selection to obtain high milk yielding strains of these breeds. Along with the maintenance of other breeding records the systematic recording for fat for each individual animal has been started from this year and this should in course of time yield very valuable information.

II. TRAINING AND EDUCATIONAL WORK

The fifth group of 19 students of the Indian Dairy Diploma course admitted in October 1931 continued its training during the year and had terms at the farms at Karnal, Wellington and Bangalore. One repeat-course student was admitted on the 5th June, 1933.

One post-graduate student who had left the course on the 12th August, 1931, was readmitted on the 6th July, 1932, and completed his training. One more post-graduate student was admitted on the 3rd February, 1933.

Short courses of practical training in different branches of dairying, varying in periods from two to six months, were given at the farms at Bangalore and Karnal to three students from private dairies and Indian States.

Twenty-eight British soldiers were given vocational training during the year in practical dairying and 15 more British soldiers were admitted on 1st June, 1933, for a similar course of training.

An examination of the Dairy Diploma course was held in December, 1932, at the Allahabad Agricultural Institute and out of 10 students who sat for the examination 8 passed, one with honours.

III. EXPERIMENTAL AND RESEARCH WORK

Bangalore. The development of the Scindi breed by selective breeding to produce a high milk-yielding strain has been continued. The same nature of work has been started on another Indian breed, the Gir, by founding a small herd this year.

The work on the weaning of calves at birth for Indian breeds and their economic hand-rearing is being continued.

An important experiment on the feeding of dairy cows has been started with the assistance of the Physiological Chemist, *viz.*, the effect of feeding of rations with a high protein content to dairy cows on the quantity and quality of milk, lactation period, body weight, heat period, subsequent calving, etc.

In addition, experimental work was carried out on—

Feeding of bone-meal to Scindi cows to see whether that would cause the animals to come in heat earlier after calving or prevent repetition of services ;

Manufacture of experimental cheeses to demonstrate the effect of varying percentages of fat in milk on the quality and yield of cheese.

Wellington. The following investigations are being conducted—

- (1) Effect of feeding bone-meal on occurrence or recurrence of oestrus.
- (2) Daily variations in fat per cent. of milk of individual cows during lactation.
- (3) Effect of feeding lucerne on milk yield.
- (4) Sex ratio of calvings in relation to advancement of heat at the time of service.
- (5) Collection of statistics from old records pertaining to—
 - (a) Mortality among calves in rearing them on the "weaning system".
 - (b) Proportion of male or female calves born.
 - (c) Effect of heat on yield of milk.

Karnal. The breeding experiments on the Haryana and Tharparkar breeds of cattle on the same lines as last year were continued. Both breeds have risen in milk yield and records of over 8,000 lb. per lactation have been obtained. By the system of recording fat percentage of individual cows which was started this year, it has been found that Indian breeds can yield as high as 7.8 per cent. fat, whereas instances of animals giving 6.5 per cent. fat are quite common. The weaning of calves at birth and their hand rearing is being continued.

An experiment on the feeding of rice and wheat straw to young stock was started with the help of the Physiological Chemist to determine the comparative feeding value of these roughages.

In addition the following investigations were carried out :—

- (1) Trial of hormone injections on animals for accelerating the heat.
- (2) Recording of butter fat tests of individual cows of Tharparkar and Haryana breeds.
- (3) Testing of samples of bazar milk for fat contents for comparison with the Karnal dairy standard.

In addition to the aboveenumerated work at the three farms, the following investigations were undertaken by the post-graduate students at Bangalore and Karnal :—

- (1) Determining the keeping quality of milk after pasteurisation and re-pasteurisation.
- (2) Increase in the body weight of dairy cows in relation to their foetal development.
- (3) Milk yield in relation to calving intervals in dairy animals.
- (4) Efficiency of milk production in relation to size in the case of dairy cows.
- (5) Relation of the weight and size of calf at birth with that of its dam and sire.
- (6) Seasonal variations in the quantity and quality of milk in the case of Haryana and Tharparkar herds at Karnal.
- (7) Observations on the correlation between the red and grey shades of colour and the milk yielding capacity in the case of Haryana and Tharparkar breeds.

IV. PUBLICATIONS OF THE YEAR

Articles sent for publication were—

- (1) "Observation on the regularity of breeding in the case of cows of the Haryana and Tharparkar breeds", by Mr. C. N. Dave, Post-graduate student.
- (2) "Determination of Live Weight of cattle by measurement", by Mr. Sodhi Gambhir Singh.

V. CO-OPERATION WITH OTHER SECTIONS AND DEPARTMENTS

This Section fully co-operated with the Physiological Chemist's Section in providing it with the facilities required for its experimental work in the form of cattle, fodder, feeds, etc. The co-operation received from that Section in the starting of important experiments, advice on feeding matters and in the training of students is very much appreciated.

The Botanical Sub-Station at Karnal was offered help in trying their wheat varieties on a field scale.

The Veterinary Research Institute, Muktesar, was provided with animals and other facilities for trying the experiment on immunization against rinderpest by the direct goat virus method.

VI. ADMINISTRATION OF FARMS

The following detailed reports from the Superintendents of the farms regarding the administration of the farms are submitted. The main features regarding the working of these farms have already been commented on by me in the introductory paragraph to this report :—

KARNAL

Mr. A. Lamb was in charge of the farm up to 28th March, 1933, and Mr. M. C. Rangaswamy held charge of the current duties of the office of the Superintendent for the period 29th to 31st March, 1933.

The market showed a slight improvement over last year except in the case of dairy produce. The climate was also slightly more favourable.

There was a net profit of Rs. 15,626 during the year on the commercial side compared with Rs. 3,204 in the year 1931-32. This was mainly due to the climatic conditions being on the whole

more favourable than last year and also due to a rise in the market rate of wheat sold, and to a decline in the purchase price of the main articles of cattle rations.

There was a net decrease in capital assets mainly due to writing off annual depreciation. The decrease in receipts is due to less outlay on cultivation and dairying due to financial stringency.

The comparative figures of sale rates of dairy produce given below show a decrease :—

	1931-32 Rate per lb.	1932-33 Rate per lb.
Fresh milk	Rs. 0-1-0 to 0-1-6	Rs. 0-0-6 to 0-1-3
Butter table	Rs. 1-2-0 to 1-4-0	Rs. 1-0-0 to 1-4-0
Cream	Rs. 0-14-0 to 1-0-0	Rs. 0-12-0 to 0-14-0
Cream on butter outturn .	Rs. 0-12-0	Rs. *0-10-0 to 0-11-0
Ghi	Rs. 0-8-9 to 0-12-0	Rs. 0-6-1 to 0-9-0
Separated milk	Rs. 0-0-6	Rs. 0-0-3 to 0-0-6
Cheese	Rs. 1-4-0 to 1-6-0	Rs. 1-2-0 to 1-6-0

*Wholesale on butter outturn to Military Dairy Farms or to others at Delhi or equivalent distances.

The disposal of milk or its products still remains a problem. The low local market rate precluded our selling to the public at Government sanctioned rates and the only alternative then was to separate the cream and sell to the Military Farms Department on the butter outturn and feeding the surplus separated milk to livestock. When, however, the Military Farms did not require as much cream as the farm produced, recourse had to be made to *ghi* manufacture which proved unremunerative owing to the low rate for *ghi* in the local districts.

The 1,981 acres of farm land was utilised approximately as follows :—

	Acres
Home cultivation	118.5
Batai cultivation	1,046
Grazing areas and waste land	261.5
Cash rental	298
Buildings and roads, etc.	257

1,981

In the case of home cultivation the rotation followed was *just* in the *kharif* season and wheat and gram in the *rabi* season (about 1/2 the area was down to wheat and half to gram). A small area of 4 acres was also sown with oats.

Wheat and gram are grown in the *rabi* season. The straw could be utilized as dry fodder for cattle and the grains can easily find a sale. Gram and wheat are sown in half the area of each plot, as it is difficult to get canal water if all the area is put down to wheat only.

The average outturn of crops is given below :—

Crops	Home outturn Mds. per acre	Batai outturn Mds. per acre	Remarks
Rice	*	12·8	In the case of Batai the outturn includes both the tenant's and Farm's shares.
Gram	23·5	11·6	
Oats	13·75	*	
Wheat Punjab 8-A	25·9	17·8	*Not sown.
Wheat Pusa 114	15·4	18·2	
Wheat 20-1	10·5	*	
Wheat Pusa 112	*	10·0	
Rice Straw	*	13·2	
Green <i>juar</i>	311	Sold standing	
<i>Bhusa</i> wheat and gram	18·3	18·2	

Comparative yield of crops for the last three years is given below :—

Grains	1930-31	1931-32	1932-33
	Mds.	Mds.	Mds.
Rice	2,956	4,879	3,250
Wheat	3,796	2,985	3,580
Gram	4,058	4,022	5,731
Peas	132	124	..

Fodders	1930-31	1931-32	1932-33
	lb.	lb.	lb.
Green <i>juar</i> fed green	3,13,530	7,48,985	2,76,164
Dry <i>juar</i> . . . . .	..	1,16,174	..
Green maize fed green . . . . .	..	..	40,657
Dry maize (maize <i>kurby</i>) . . . . .	..	..	7,180
Hay	1,23,155	76,138	1,18,476
<i>Bhusa</i> (gram and wheat)	12,71,103	6,28,604	6,98,694
<i>Chari</i> silage	45,19,260	58,70,123	15,51,840
Grass silage . . . . .	..	..	1,68,388
Anjan grass seed . . . . .	..	..	53
Green grass fed green . . . . .	..	..	14,378
<i>Poolas</i> (thatching grass) . . . . .	..	..	80½ mds.
Rice straw	2,15,373	6,28,604	3,332 mds.

The strength of the livestock of the farm at the beginning and the end of the year was as follows :—

	1-4-32	31-3-32
Cows	126	132
Buffaloes	13	12
Cow bulls	5	8
Buffalo bulls	1	2
Cow young stock males	109	53
Cow young stock females	101	108
Buffalo young stock males	9	3
Buffalo young stock females	23	7
Bullocks	24	26
Horse	1	1
Sheep—Ewes	93	32
Rams	6	4
Female lambs	93	66
Male lambs	46	2
Total	650	456

The reduction in numbers was due to retrenchment in young stock males and sheep at the beginning of the year.

One hundred and two cow calves and 14 buffalo calves were born during the year.

Up to the middle of February 1933, all calves having colour not true to its type were discarded. After that date some of the above class out of exceptionally high yielding dams and granddams are

being retained to experiment about their change of colour, etc. Some of the heifers and male calves of high yielding granddams are also retained which were discarded previously.

Up to the date mentioned in the previous paragraph, service to the cows was given after 3 months from calving, but it has been now regulated from first heat to 3 months, according to the number of calving, milk yield and condition of the animals. Heifers are covered between 2½ and 3 years of age.

Feeding is done according to the approved scale of feed in consultation with the Physiological Chemist to the Government of India.

Breeding is carried on with a view to fixing high milking strains in all the three breeds on the farm. The majority of farm-bred heifers coming into the herd conform to the breed points and retain good milking qualities. The proportion of purchased animals has been reduced in a period of 10 years to 27 per cent. among cows and 25 per cent. among buffaloes. These include animals purchased from military dairy farms and provincial farms for basic stock.

Average milk yield of cows in a lactation, 1932-33

Breeds	Average milk yield	Average No. of days in milk	Average days dry
	lb.		
Tharparkar.	4,035	272	99
Hariana	3,644	300	82
Buffaloes	4,741	299	104

A comparison of the over-all averages of the herd for three years shows improvement from year to year in all breeds. This is due to new farm-bred heifers coming into milk and weeding out of less profitable animals.

Over-all averages of different breeds

Year	Tharparkar	Percentage of increase over previous year.	Hariana	Percentage of increase over previous year	Buffaloes	Percentage of increase over previous year
	lb.		lb.		lb.	
1930-31 .	6.2	..	5.6	..	8.6	..
1931-32 .	7.8	26	7.6	35	10.4	22
1932-33 .	9.3	23	8.4	23	13.0	25

The six best animals of each breed to complete their lactation in 1932-33 were as follows :—

No.	Animal No.	Age	Milk yield during 1932-33	Days in milk	Remarks
		Yr. M.	lb.		
			<i>Tharparkar</i>		
1	119	14 0	7,708	386	
2	256	7 10	5,819	361	Farm bred.
3	272	8 0	6,755	307	"
4	295	7 9	6,644	320	"
5	306	6 6	7,005	336	"
6	387	6 1	7,595	512	"
			<i>Hariana</i>		
1	128	12 0	6,193	432	
2	142	12 9	5,417	279	
3	242	8 5	5,746	280	Farm bred.
4	302	7 2	6,567	305	"
5	414	5 5	5,091	347	"
6	423	5 2	5,097	366	"
			<i>Buffaloes</i>		
1	10	13 0	5,421	306	
2	19	12 0	5,041	210	
3	21	7 7	4,414	200	Farm bred.
4	40	6 11	6,398	343	"
5	45	5 10	7,598	463	"
6	48	5 8	5,204	334	"

Rearing of calves. As a general rule calves are weaned at birth and this has been successful in most of the cases. The hand-fed calves get mother's milk from birth up to a month and afterwards separated milk is added to their milk ration.

Mortality. One cow, 7 calves, 1 buffalo-calf and 5 sheep died from natural causes. There was a mild outbreak of foot-and-mouth disease from the 7th May to the 5th June, 1932, and was confined

to cow young stock only. Fifty-one animals (5 cows, 45 cow young stock and 1 buffalo young stock) were inoculated against rinderpest. Except the nine older animals, all were done by the virus alone method. Eighteen cow young stock and three buffalo young stock were given rinderpest inoculations (virus alone method) by the staff of the Imperial Institute of Veterinary Research, Muktesar, to test the immunity of calves of protected and unprotected dams.

Herd testing for butter fat was undertaken under two heads from September, 1932 :—

- (i) Tharparkar and Haryana cows mixed milk separately for each herd.
- (ii) Each animal of both the breeds, from the date of calving to dry.

Under (i) only seven months tests are available which cover a part of the summer season and the whole of winter. Average cannot be taken yet unless the tests are taken for the complete year.

Under (ii) 51 animals, out of 132 heads (of both the breeds), have calved and their milk taken under testing and the rest would be brought under test as they calve. It will take at least one year more to arrive at conclusions; so far none of the animals has completed a lactation.

In December last, 12 samples of bazar mixed milk as sold by shopkeepers were obtained. It is generally believed by the public that it contains more of buffaloes milk than that of cows. Out of 12 samples, 4 were up to the mark as compared with dairy milk, and the rest were all below the standard. The highest test was 5.9 per cent. fat and the lowest 1.3 per cent. fat.

The Farm was visited during the year by 28 delegates of the Board of Agriculture and Animal Husbandry. The Professor of Agriculture, Punjab, and the Statistician, Imperial Council of Agricultural Research, also visited the farm. Students from the Khalsa College and also from the Punjab Agricultural College were shown round the farm.

A demonstration of an up-to-date dairy was arranged at the local Health and Baby Week.

BANGALORE

Mr. S. Cox was in charge of the farm until the 5th April, 1933, when he proceeded on leave to England and Mr. A. Lamb assumed charge.

Owing to heavier and better distribution of rains during the cropping season, compared with the previous year, the outturn of farm grown fodder was more favourable and the cost of production thereby reduced.

The financial position under commercial activities shows an improvement as can be seen from the following figures :—

	1932-33			1931-32			1930-31		
	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.
Profit	18,253	8	0	1,238	12	1	1,000	7	2

This is due mainly to a decrease in the size of the herd entailing less expenditure on feed and keep. In addition, economies in expenditure were effected in other directions.

Receipts. Comparative figures for three years are as follows :—

	1932-33			1931-32			1930-31		
	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.
	1,16,560	10	3	1,27,077	3	2	1,27,720	1	6

(A reduction of 8·3 %).

The lower receipts during the year were mainly due to sales of dairy produce having been restricted, under Government orders, to the Military. The year under review being a resting year for coconut trees the rent of Rs. 4,500 for tapping was not also collected as was done in both previous years.

Trade. The sales of dairy produce in the first and second half of the year were as follows :—

	1st 6 months		2nd 6 months	
	lb.		lb.	
Milk	1,64,528		1,51,867	
Butter	15,139		15,364	
Cream	1,266		1,378	
Cheese	504		494	

The only item showing any large variation is milk and the decrease in sales of this article was due mainly to restriction of sales to the military.

Cultivation. The same policy continues as has been followed for many years, i.e., to keep under a permanent green crop as much land as the water available for irrigation permits. This consists of about 9 acres of Guinea grass, $\frac{1}{2}$ acre of Rhodes grass and $\frac{2}{3}$ acre of lucerne. These crops give a continuous green fodder supply all the year round of considerable value to the herd.

The remaining cultivable area of 55 acres is used annually for a monsoon crop, usually *juar*, which is utilized largely for silage making.

Rotation of crops is not followed as a general rule as plenty of farmyard manure is available and also because the harvesting of *juar* is usually too late to permit of a winter crop being sown. Experiments in this direction have met with little or no success. The only fodder purchased continually is *ragi* straw, a crop not grown on this farm. The outturn of fodder crops for the last two years is shown below :—

Kind of fodder	1932-33				1931-32	
	Acre-age	Outturn in lb.	Total cost	Cost per 100 lb	Outturn in lb.	Cost per 100 lb.
			Rs. A. P.	Rs. A. P.		Rs. A. P.
Green <i>juar</i> . .	55.28	1,560,340	2,108 8 3	0 2 2	1,129,680	0 3 0
Green lucerne . .	0.68	96,448	294 13 10	0 4 11	79,104	0 12 5
Green Guinea grass	9.03	968,460	1,892 11 0	0 3 2	1,039,450	0 4 3
Green Rhodes grass	0.46	79,600	111 13 2	0 2 3	..	..
Green grass . .	..	..	..	..	..	..
	65 45	2,704,848	4,407 14 3	0 2 7	2,248,230	0 3 11
*Green <i>juar</i> . .	..	2,83,355	319 9 10	0 1 10	242,300	0 2 9
* Green Guinea grass . .	..	8,400	..	..	7,000	..
		291,755	319 9 10	0 1 9	249,300	0 2 8
Grand Total . .		2,996,603	4,727 8 1	0 2 6	2,497,530	0 3 9

* Grown at Bommanpally.

Cattle. The herds maintained consist of Scindis and cross-bred cows and a few Murrah buffaloes. In addition, 15 Gir cows and a bull were added in January 1933 as the nucleus of a Gir herd which it is intended to build up.

The feeding of the adult herd is based on the starch equivalent contained in the mixed concentrates, which consist of bran, groundnut cake, brewery grains and *gram chuni* in the proportion of 3 : 3 : 2 : 1. A pound of this mixture has a starch equivalent of 0.53 and the albuminoid ratio works out at 1 : 4.7.

Based on a live weight of 700 lb. and giving milk of 4.2 per cent. butter fat a cow gets 0.25 starch equivalent per pound of milk yielded *plus* $\frac{1}{2}$ pound of oil-cake for maintenance. Roughages are fed on a basis of 18 lb. dry matter fed as green fodder, silage or dry *ragi* straw in whatever proportions are available.

The comparative over-all averages of milk per day of all animals in the adult herd were as follows :—

	1932-33	1931-32	1930-31
	lb.	lb.	lb.
Cows (Cross-bred, Scindi and Gir).	9.6	8.6	8.1
Buffaloes	11.6	7.8	8.7

The following figures show the merits of the different classes of animals :—

	No.	Cross-breds	No.	Scindi	No.	Buffaloes
Average daily No. in herd milking .	..	70	..	51	..	8
Average daily No. in herd dry .	..	22	..	32	..	1
Average milk yield per animal which completed its lactation during the year	79	lb. 467		lb. 3,156	7	lb. 3,925
Average number of days in milk of the same animals		377		281		316

As the breeding policy is to improve Indian breeds and to reduce the cross-bred herd gradually the Scindi and Gir cows are crossed only by selected bulls of their respective breeds.

Of the 164 animals sold during the year, the large majority were of the cross-bred type, particularly young stock.

Young stock. Thirty cross-bred and six Scindi heifers bred on the farm joined the adult herd during the year. In order to control services of young stock they are brought into the Bangalore Farm when about two years old and crossed by selected bulls, returning to the dry stock farm when in calf.

Dry stock. These are sent to the Dry Stock Farm at Bommanpally where they are kept until within a few weeks of calving when they are returned to Bangalore.

All these animals together with the young stock kept there are fed concentrates and fodder the whole year round, the grazing being very scanty even during the rains.

The dry stock farm is also used for inoculation purposes, the number inoculated by the serum simultaneous method against rinderpest last year being 13 cows and 66 young stock.

Diseases. Owing to an outbreak of rinderpest in a neighbouring village in May all unprotected animals in the herd at Bangalore were given one dose of serum. No further developments occurred.

In August a death at the Dry Stock Farm was suspected to be due to anthrax. All contact animals were protected at once and no further casualties occurred.

Filaria of the eye supposed to have been introduced by animals from Wellington occurred a number of times although most cases yielded to the treatment eventually. Mr. Raghunath Rao, a Veterinary Officer of Mysore Veterinary Department, has been particularly helpful throughout the year in the matter of inoculations and advice and his assistance is much appreciated.

The usual number of interested persons visited the Institute during the year including the Agricultural Chemist to the Government of Bombay and H. H. Rani Sahib of Palitana. Forty-nine students of the Agricultural College, Coimbatore, accompanied by a Lecturer in Chemistry, visited the Institute in January 1933.

WELLINGTON

Mr. M. C. Rangaswamy, I. D. D., Supervisor, was in charge of the depot from April 1932 to November 1932 when he proceeded to Karnal to officiate as Assistant Superintendent. From December 1932 to the end of the year the depot was in charge of Mr. H. C. Verma, I. D. D. ^{and} Supervisor.

During the year under review, the Institute worked as a quasi-commercial concern with education for a month and scientific investigations as its primary function and made a profit of Rs. 6,629 on its commercial side. In accordance with Government orders, it is now treated as a "depot" for the supply of dairy produce to Military stationed in its vicinity with the restriction that supplies are not made to civilians. As a result of this changed policy of working, cows in milk were supplied according to the requirements of the Institute by the Imperial Dairy Institute, Bangalore, and were returned to that place when dry.

Purchase prices were favourable during the year. The total rainfall was a little less than in preceding years, as is shown below. Shortage of rainfall during the *rabi* season was responsible for the decreased outturn of *rabi* crops. The weather conditions during the rest of the year were normal.

	<i>Rainfall for last 3 years</i>										Inches
1932-33	50.34
1931-32	58.41
1930-31	55.37

Receipts. In general, the total receipts of the year under review indicate a drop of 45.3 and 58.3 per cent. from the two preceding years respectively. The main reason for this large decrease was the restriction made in supplying dairy produce to the Military only.

Establishment. The expenditure under this head amounted to Rs. 10,487, as against Rs. 21,914 in the previous year. This large decrease was due to the retrenchment of the post of Superintendent which was replaced by a Supervisor-in-charge on a much smaller scale of pay, and reduction in subordinate establishment.

Trade. Sales of chief dairy products for the second half of the year under review, with the second halves of the two years immediately preceding it, are compared in the table below :—

	1932-33	1931-32	1930-31
	lb.	lb.	lb.
Milk	63,893	84,173	133,429
Butter	8,160	9,565	9,665
Cream	276	218	173

The considerable drop in sales is to be ascribed to the restriction of supplies to the military.

The purchase prices of wheat, bran and ground-nut cake were higher than in 1931-32. Prices of gram husk and gram being lower, contributed to decrease the average purchase price of all concentrates combined. Paddy straw was the only dry fodder purchased during the year, as it is a necessary food for cattle and cannot be produced at the Institute.

Cultivation. The table given below shows particulars of land in acres, owned and leased by the Institute during the year under review :—

	Arable Perennials	Arable Seasonal crops	Grazing	Forest for fuel	Buildings and roads	Total
Owned	5.5	28.65	21.61	7.0	6.08	68.84
Leased . . . . .	..	5	*90.01	..	..	95.01
Total	5.5	33.65	111.62	7.0	6.08	163.85

*90.01 acres of leased land include 86.01 acres of land rented for only 4 months in the year.

The following table shows how the arable land indicated above was distributed for cultivation, and the rotation that was followed :—

	Acres	Kharif	Rabi
(a)	5	Perennial	Rhodes and Guinea grass.
(b)	$\frac{1}{2}$	„	Lucerne.
(c)	2 $\frac{1}{2}$	Potato	Wheat and cabbage.
(d)	1 $\frac{1}{2}$	Juar	Potato.
(e)	13 $\frac{1}{2}$	„	Oats and ragi.
(f)	14	Maize	Oats.
(g)	2.15	Bajra	Oats and mangolda.
	39.15		

The table given below shows comparative yields of crops for the last three years:—

	1932-33	1931-32	1930-31
	lb.	lb.	lb.
Rhodes grass and Guinea grass	138,555	177,115	116,020
Lucerne	15,435	..	6,475
Maize	103,990	118,210	20,800
Juar	126,655	52,125	116,710
Sun-flower	2,400	..	..
Bajra	19,900	12,070	..
Wheat	11,535	..	..
Oats	58,140	236,305	138,790
Ragi	1,700	32,435	..
Cabbage	8,800	14,285	..
Mangolds	520	..	..
Total available food for cattle	492,630	642,545	398,795
Potatoes (Cash crop)	33,384	38,090	57,010
Total	526,014	680,635	455,805

The seasonal crops most suitable in this part are maize, *juar*, oats and wheat for the supply of green fodder, with occasional supplementing with cabbage, mangolds, *ragi* and *bajra*. These give large yields and are economical to grow. During the year under review, green fodder was produced at 0-9-1 per 100 lb. as against the market rate of about rupee one for the equivalent quantity.

Guinea grass, Rhodes grass and lucerne form good perennials and yield a continuous supply of green fodder throughout the year.

The most remunerative cash crop is the potato. Several varieties such as Early Market, Arran, Comrade, King Edward and Great Scot are grown. During the year under review an outturn of about 14,000 lb. per acre was obtained at the production cost of about 13 annas per 100 lb. The following table shows comparative sale prices of potatoes for the last three years. It will be seen that although the sale price of potatoes during the year fell considerably, yet the profit made on every 100 lb. was more than Rs. 1-12-0:—

	Sale price
	Rs. Per 100 lb.
1932-33	2 4 5
1931-32	5 1 7
1930-31	3 5 7

Cattle. In accordance with Government orders, "cattle-breeding experiments" were not conducted during the year. The table given below compares (1) Milking average per diem per head of milking cow and (2) Over-all average of the year under review with the figures of the year preceding it :—

				Milking average per diem per head of milking cow	All-over average
				lb.	lb.
1932-33	.	.	.	18.35	18.13
1931-32	.	.	.	14.11	8.73

There was an increase in both the averages during the year. Milking average per diem per head of milking cow discloses true performance of the milking cattle at the time, but the over-all averages are calculated on the basis of the few dry cattle which had to be kept here for reasons of health and advanced gestation. The table given below shows the comparative production cost per lb. of milk for the last 3 years :—

				Per lb.		
				Rs.	A.	P.
1932-33	.	.	.	0	2	9.9
1931-32	.	.	.	0	4	8.4
1930-31	.	.	.	0	7	2.7

The reduction in production cost is to be attributed to the revised policy of working this Institute, combined with economies in expenditure all round.

There was no outbreak of any epizootic diseases during the year and the health of the animals in general remained satisfactory. Three cows and two calves died of common diseases.

SCIENTIFIC REPORTS

OF THE

Imperial Institute of Agricultural Research, Pusa

*(Including the Reports of the Imperial Dairy Expert,
Physiological Chemist and Sugarcane Expert)*

1933-34



26073/136

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Scientific Reports of the Imperial Institute of Agricultural Research, Pusa

*(Including the Reports of the Imperial Dairy
Expert, Physiological Chemist and
Sugarcane Expert)*

1933-34

REPORT OF THE DIRECTOR

[F. J. F. SHAW, D. SC. (LOND.), A.R.C.S., F.L.S., I.A.S.,
AND M. WYNNE SAYER, B.A., DIP. AGRI. (CANTAB.),
I.A.S.]

I. GENERAL

The outstanding feature of the year under review was the occurrence of a very severe earthquake at about 2-10 P.M. on the 15th January, 1934. The shock which was one of the most severe ever recorded in India, caused wide-spread damage in Bihar. The epicentre of the shock and the zone of greatest damage was approximately on a line running from Motihari through Muzaffarpur to Monghyr and practically passed through Pusa. The Phipp's Laboratory suffered very severely, both wings being wrecked and the structure of the main building being so badly damaged as to be irreparable. All laboratories in the Phipp's Laboratory had to be vacated and arrangements made to carry on the scientific work on a reduced scale in such small buildings as were available and habitable. Work in the chemical, mycological and entomological sections is now proceeding under great difficulties of space and equipment.

A considerable amount of apparatus was broken and damaged and will have to be replaced, but whole of the library was saved. The decision of the Government of India to transfer and rebuild the Institute at Delhi will place the Institute in a position in which it will be much more efficient and of much greater service to Indian agriculture.

II. RESEARCH AND PROGRAMME OF WORK

SOIL FERTILITY

Indian soils have, in general, a low content of nitrogen, and the ryot uses little or no nitrogenous manures. Though climatic conditions result generally in active nitrification, the average crop-yields are low and the maintenance of an adequate supply of nitrogen in Indian soils constitutes one of the important problems facing agricultural research workers. Studies of the nitrogen balance sheet, the factors influencing nitrogen fixation, and practical measures such as the use of leguminous crops and green manures are, therefore, of great interest and importance.

The experiment to determine the influence of leguminous crops in conserving the soil nitrogen when grown in mixture or in rotation with a cereal has now run for four years, and, as in previous years, a gain in soil nitrogen was noticed in all plots in both the *kharif* (summer) and *rabi* (winter) series after taking into consideration the nitrogen removed by the crops. The highest gain in the *kharif* series was 415.8 lb. per acre with a mixed crop of maize and *urid* (*Phaseolus radiatus*) and in the *rabi* series of 364 lb. with a mixed crop of barley and field peas. A statistical analysis is being made of the economic return obtained as well as the nitrogen gained by the soil with a view to ascertaining which system of cropping is superior from both points of view.

Investigations in the laboratory have shown that changes in the seasonal temperature affect the nitrifying flora in the soil to a great extent and cause two periods of depression in May and November. Soil samples taken in June are comparatively richer in nitrifying organisms: they nitrify both *surson* cake and ammonium sulphate completely within four weeks. Silt thrown out by the earthquake has not been found to differ very much from the normal Pusa soil, but the sand is poorer in total nitrogen and nitrifying flora.

The field experiment started three years ago to find cheaper but equally efficient alternatives to sann-hemp as a green manure has not yielded results in favour of either *urid* (*Phaseolus radiatus*) or soybean (*Glycine hispida*). Whether whole sann-hemp plants are ploughed in or only the tops are buried and the stems are utilized for extracting fibre, the succeeding crop of wheat is better and the residual effect more lasting. The difference in the value of produce obtained with the two methods of utilizing sann-hemp as a manure is not significant. The experiment on the possibility of securing green-manure from land already growing another crop was again carried out. As in previous years, Mexican sunflower (*Tithonia diversiflora*) was planted in land carrying a crop of onions. Expressed in yields per acre, 116.8 maunds of onions and 93 maunds of

sunflower were obtained as against 125·9 maunds of onions from control plots growing that crop alone. The low yields of sunflower, as compared with previous years, can be ascribed to the fact that the earthquake delayed planting and disturbed the arrangements for irrigation. The effect of burying in sunflower is marked on the yields of succeeding *khari* and *rabi* crops but the economics of the cropping system as a whole are yet to be worked out.

✓ *Katwa sewar* (*Hydrilla verticillata*), an aquatic plant growing abundantly in river beds, having been found to ferment quickly in the soil, is being tried as a manure. In preliminary trials, plots manured with *sewar* have yielded 44·5 per cent. more corn than those receiving farmyard manure.

Apricot seed-cake has proved an efficient nitrogenous manure for soils which are deficient in this constituent, and especially so in agricultural lands in the neighbourhood of Solon in Simla Hills where it is available in plenty but is at present used as a fuel. The application of 80 lb. of nitrogen per acre produces the maximum yield of wheat whether the soil used is from Pusa or Solon, but the residual effect in Pusa soil is not significant unless the dose is raised to 100 lb.

Among other investigations bearing on the maintenance or improvement of the fertility of soils may be mentioned those intended to elucidate the lime requirements of acid soils of Assam, the limiting factors of phosphate and potash requirements in calcareous soils, the relative availability of natural and artificial phosphates in calcareous soils, and the apparent ineffectiveness, or even depressing effect, of potassic fertilizers in Pusa soil. Pot experiments designed to determine the depth of soil at which superphosphate can most profitably be applied in Pusa soil have shown that best results with a crop of mustard are obtained when the manure is placed four inches below the surface.

IMPROVEMENT IN YIELDS AND QUALITY OF AGRICULTURAL PRODUCE

The plant breeding work at the Institute is directed towards providing the Indian cultivator with high yielding types of crops and improving the quality of agricultural produce. The quality of agricultural produce depends upon its uniformity, its purity and its possession of some intrinsic property, *e.g.*, high gluten content in wheat, oil content in linseed, disease resistance in pigeon-pea. This section of the report is mainly concerned with what is being done at Pusa and Coimbatore in this respect.

Wheat.—Of the total acreage of over 30 million acres under wheat, about 3 million acres are under the celebrated Pusa wheats—Pusa 4, Pusa 12 and Pusa 52—which are superior in yield and quality to the *desi* wheats. In addition, two new wheats have

recently been produced, one of which (Pusa 111) has been tested in England and pronounced equal in quality to the best Canadian wheat; in this new wheat India possesses a grain which may enable her to compete in the export trade. The other wheat (Pusa 114) has proved extraordinarily successful in the area under the Sukkur Barrage and, on account of its disease resistance and quality, has sold in Sind during the year under report at a premium of 12 per cent. over the local wheats. The breeding work at Pusa has yielded other strains which promise to meet the special requirements of certain areas. In a season which was characterized by an unusually severe incidence of rust, Pusa 101, a cross between Muzaffarnagar and Pusa 22, proved an outstanding yielder, acreage yields under such varying conditions as at Pusa and Meerut being 2,584.4 and 2,715.4 lb. respectively. It is reported to have possibilities for spreading in Bhopal State where a rust-resistant wheat is badly required. Through its freedom from lodging and black rust on the Karnal Sub-station, Pusa 80-5 has come to be widely appreciated in the Punjab where its seed is much in demand by the local Agricultural Department. Although most of the hybrids obtained from crosses between the Australian variety Federation and Pusa 4 and Pusa 52 have not been found superior to the Indian parents in yield, some of them nevertheless possess certain desirable features such as resistance to disease which may render them of agronomic value. Two of them, designated Pusa 120 and Pusa 165, are under test on various farms in the Punjab and in the United Provinces and the results are being awaited with interest.

Oats.—The 11 hybrids fixed by crossing Pusa types with Abundance and Scotch Potato were tried for the third time simultaneously at Pusa (without irrigation) and Karnal (under irrigation) against the standard Pusa types B. S. 1 and B. S. 2. The accumulated results of three seasons' trials at each place show that the five highest yielders are B. S. 2, B. S. 1 and Hybrids C. J. and G which are ranked in this order but B. S. 1 and Hybrids C. J. and G are not statistically different from each other and may all be classed as yielders of the same order. Amongst these five oats B. S. 2 is statistically superior to hybrid G only and not to any others. Hybrids A, B, H and K, on the other hand, have not done well and must be ranked as indifferent yielders. Favourable reports regarding the yielding power of B. S. 1 and 2 and Hybrids C and J have been received from many parts of India where they have been tried during the year under report. At the Byreah Farm of the Bettiah Raj in North Bihar, B. S. 1 significantly out-yielded hybrids C, F and J.

Barley.—All the 24 types of barley isolated at Pusa having been found susceptible more or less to a serious disease caused by *Helminthosporium*, which is only partially controlled by seed treatment, a study of the inheritance of resistance to this disease has been

linked up with breeding work. The present indications are that resistance to disease is dominant to susceptibility.

Paddy.—In a preliminary yield trial with the most promising of 123 types isolated, one autumn paddy (Type 18) and three winter paddies (Types 24, 31 and 52) have been picked out as being worthy of large seed tests.

Linseed.—The yield trial experiments intended to test certain hybrids obtained by crossing the high-yielding Pusa types of low oil content with low-yielding Central Indian varieties of high oil-content against standard Pusa Type 12 were vitiated by a severe incidence of rust (*Melampsoralini*). With a view to combining in one type high yield, high oil-content and resistance to rust, certain bold-seeded Australian linseeds which are immune to rust have been crossed with the high-yielding indigenous types and fixed hybrids. The best of these hybrids will it is hoped make India, with the Ottawa preferences in her favour, retain an even larger share of the export trade to the United Kingdom and of the quality market of the Continent. The Crop Planning Conference considered that India could probably increase her linseed area by two million acres, but that progress would depend largely on the spread of improved types.

Sesamum.—Cross-breeding has been resorted to for producing a highyielding, white-seeded strain: the trade prefers white-seeded types for the lighter-coloured oil they yield.

Gram.—Though at Pusa and at Karnal, Type 58 failed to repeat its performance of previous two years in out-yielding Type 17, it, along with Types 51, 54 and 55, did significantly better than the other established Type 25. Type 58 is, however, reported to have given higher yield than T 17 on various other experiment stations. The hybridization work in progress at Karnal continues to give information on the inheritance of various characters.

Pigeon-pea.—In a yield trial with 10 promising types isolated, Types 24 and 64 again proved significantly better yielders than local seed. At Sabour where Pusa Types 15, 16, 41, 50, 80 and 82 were grown, the wilt-resistant Type 80 occupied the first position, while Types 24 and 51 did fairly well on the Sepaya Farm. Type 51 is reported to have shown resistance to frost injury on the Gwalior Farm.

Indian hemp.—Pusa Types 1 and 2 of *ganja* were cured for the first time during the year under review. Type 1 appears to be a very promising strain for the production of the drug and seed is being multiplied for large-scale trials. About 160 lb. of seed were obtained from a crop of this type in an area of about one-fourth of an acre.

Tobacco.—As stated in previous reports, the problem of meeting the ever-increasing demand for a higher and brighter tobacco has

been tackled in the Botanical Section by crossing a local type (Type 28) with an American Adcock and fixing certain hybrids which are breeding pure within narrow limits. The large growings of one of these hybrids (Type 142) for flue-curing this year produced a fine crop and some very good quality leaf was cured before the crop was damaged by a hailstorm in the middle of January. Some 1,500 flue-curing barns worked on the principles evolved at Pusa are now in operation in districts which are suitable for this industry, *viz.*, Guntur in Madras, Saharanpur in the United Provinces and in North Bihar, and the capital expended by commercial concerns in constructing them is approximately 15 lakhs of rupees.

Indigo.—In the course of experiments carried on in the Chemical Section with the object of bringing the natural indigo paste into a colloidal state and maintaining it in such state without fermentation, sodium salicylate has proved a better preservative than sodium carbonate in that subsequent heating in the air oven can be dispensed with. Natural indigo paste as available immediately after the *mahai* mixed with 5 per cent sodium salicylate and kept in sealed tins has been found after four months unchanged and free from fermentation. It is now proposed to give dyeing trials with indigo paste preserved with sodium carbonate and sodium salicylate and see how they compared with ordinary natural indigo cake as marketed at present.

Sugarcane.—The improved types of thin and sub-tropical canes bred at the Imperial Cane-breeding Station at Coimbatore covering as they do half the total area under the crop have raised the average yield per acre for the whole of India from eleven to fifteen tons. They have rendered possible the enormous development of the white sugar industry in North India which promises to make India in the near future independent of foreign imports. Certain of these sub-tropical canes, particularly Co. 213, Co. 281 and Co. 290, are finding favour even in typically tropical parts of India as well as in foreign countries such as Argentine, Louisiana, South Africa and Australia. The last two mentioned would appear to have revealed unsuspected resources of both drought and disease resistance, outrivalling a cane of such outstanding merit in this direction as Uba. The remarkable way in which Co. 223 is working its way in the Kangra District of the Himalayas and at altitudes of over 4,000 feet above sea level is a noteworthy development. Among the new canes, Co. 313 and Co. 331 continue to fulfil their early promise, and there are indications that Co. 349 might prove one of the canes of the future. The breeding of new seedlings which will give heavy yields under a wider range of conditions than those for which the present popular Coimbatore varieties are suitable is being actively carried on and the technique of breeding is being gradually perfected. This work is expected to be accelerated with the development of

the sub-station at Karnal financed by the Imperial Council of Agricultural Research. Last two years' experience has shown that maximum advantage of the sub-station can be obtained by effecting the desired crosses at Coimbatore at the beginning of the arrowing season and transporting the young seedlings to Karnal for planting at the usual time for canes in the tract. Thus handled, the seedlings show normal growth and allow of preliminary selections being made at the end of their first year at Karnal.

Among the first batch of thick canes distributed three years ago, there are some which have already begun to attract attention in agricultural stations in North as well as in South India. Co. 408, 413, 407 and 402 are doing well at Karnal (Punjab), Shahjahanpur (United Provinces), Jorhat (Assam) and Padegaon (Bombay Presidency) respectively. With the distribution of 11 more seedlings during the year under report the number of tropical canes under trial has been brought up to 32.

Sugarcane-sorghum hybrids are still being tested and a few of them may prove to be the earliest to mature during the ripening period for canes in that area. Particularly Co. 356 has shown promise of usefulness in more than one North Indian Station. In the Madras Presidency where these hybrids have been planted and analysed every month, some of them are reported to attain a purity of 85 and over in about 200 to 220 days from the time of planting and tend to improve in quality for nearly 100 days afterwards. Further, "the juices of sorghum hybrids at the point of their maximum efficiency were decidedly richer than those of other Coimbatore canes".

At Pusa, an independent area of land measuring 150 acres is mainly devoted to sugarcane experiments. The testing of new Coimbatore canes for yield and other characteristics, tonnage trials with selected varieties, manurial experiments and general problems of cane cultivation form the basis of the work. The impending trials of Co. 281 as a semi-irrigated cane to replace Co. 213 and of Co. 331 as a heavy tonnage late ripening cane for April crushing had to be postponed indefinitely owing to the dislocation caused by the earthquake of January 1934, but a mill test was carried out on 19th November 1933 at the Samastipur Central Sugar Factory with Co. 299 which promised to be an early cane like Co. 214 without its bad agricultural habit and poor tonnage yields. The mill trial results have shown that a definite saving in raw material cost can be effected by the substitution of Co. 299 for Co. 214.

PLANT DISEASES

The work on the mosaic disease of sugarcane financed by the Imperial Council of Agricultural Research has yielded useful information on the nature of mosaic virus and the organisms associated

therewith, for details of which reference is invited to the Report of the Imperial Mycologist. The experiment on the effect of mosaic on the tonnage and juice of sugarcane was extended to Patna and Cawnpore, and it would appear from the following figures that the effect was marked and significant under different soil conditions and that the loss was more in the irrigated crops at Patna and Cawnpore than at Pusa where no irrigation was given.

Percentage loss due to mosaic

	In tonnage.	In calculated juice.
Pusa	11.9	12.94
Patna	15.0	19.40
Cawnpore	15.9	17.08

Amongst the new diseases of sugarcane under study may be mentioned the red stripe disease reported last year which is now known to occur throughout sub-tropical India, a stinking rot of bacterial origin observed for the first time at the Sugarcane Research Station at Mushari in Bihar, and a seedling disease found in the nurseries at Coimbatore, the symptoms of which are like those of foot-rot caused by *Helminthosporium sativum* in wheat. Dusting with RV, sulphur had no beneficial effect on plants affected with top-rot disease caused by *Fusarium moniliforme*.

Attempts to combat the stem-rot of *Hibiscus sabdariffa* caused by *Sclerotinia sclerotiorum*, which appears in January, by early sowing met with disappointing results, for whether the crop was sown in April, May or June, it was ready for harvest by the end of February. Ploughing the soil rather deep after harvesting appears to be one of the methods of controlling the disease, for it is brought about by the ascospores that are formed about December when the cold weather sets in.

As a certain percentage of wilt of sann-hemp is caused by *Fusarium vasinectum* carried by seed, disinfection of seed before sowing with either uspulun (0.25 per cent.) for 30 minutes or mercuric chloride (1—1,000) for 10 minutes is indicated.

Though seed treatment with uspulun gave better results than other fungicides employed, *viz.*, copper carbonate, ceresan and formalin, it was not able to check altogether the bunt disease of wheat caused by *Tilletia indica*. As the bunt spores are well protected by the pericarp covering, it is likely that hot water treatment may be more effective than that with a fungicide.

Covered smut of oats (*Ustilago kollerii* Wille) was brought under complete control by treating the seed with formaldehyde using the dry spray method. In a hundred-acre area sown with treated seed, only two smutted heads were seen, while smut ranged from 1.5 to 16.9 per cent. on a 25-acre plot sown with untreated seed.

The experiment to test the comparative resisting power of 24 types of Pusa barleys to *Helminthosporium* was continued, and besides uspulun, cerasan was also tested as a seed disinfectant. Though both fungicides were found equally good in controlling foot and root-rots, neither prevented destruction of leaf surface which apparently is due to secondary infection taking place by means of air-borne spores. Seed treatment with formalin was not so effective in controlling the smut disease of barley caused by *Ustilago hordei* as that with uspulun and cerasan.

The investigation into the foot-rot disease of *Piper betle* in Bengal was concluded after it had been conclusively established that growing the vines above the flood level, clean culture and timely applications of Bordeaux mixture and Kerol controlled the disease.

A study of the fungus flora of soil in which pigeon-pea had been grown continuously for ten years revealed the presence of *Fusarium vasinfectum* up to a depth of two feet. Among other fungi commonly found were species of *Aspergillus* *Necosmospora vasinfectum*, *Mucor* sp. and three Ascomycetes. The number of colonies of fungi decreased with the increase in depth.

Among other diseases under investigation may be mentioned those of wheat caused by *Helminthosporium*, *Ustilago* and *Puccinia* the sclerotial diseases of rice, leaf blight of gram caused by *Mystrosporium* sp., stem and root-rots of tobacco and the *phurki* disease of *Amonum subulatum*. Further survey of diseases of fruit trees in British Baluchistan was undertaken during the year and several fungi were recorded there for the first time.

INSECT PESTS

As in previous years, sugarcane borers and other insect pests of sugarcane received considerable attention in the Entomological Section. In a detailed examination of the previous year's sugarcane crop covering an area of 1·95 acres, made from the 17th March to the 11th May 1934 with a view to determining the incidence of the major pests of sugarcane, it was found that the percentage of healthy canes varied from 21·10 to 45·41 per cent. The percentage of infestation was observed to vary as follows in different cases :—

	Percentage of infestation.
Top-shoot borer (<i>Scirpophaga nivella</i> Fb.)	11·55—35·37
Stem-borer (<i>Chilo zonellus</i> Swinh., <i>Argyria stictic-raspis</i> Hmp. and <i>Diatraea venosata</i> Wlk.)	2·33—8·01
Root borer (<i>Enmalocera depressella</i> Swinh.)	3·2—11·55
Termites	1·48—7·82

A similar survey made of the mosaic tonnage experimental plots at the time of the harvest in February-March 1934 revealed the

damage by the top-shoot borer among mosaic infested canes to be 17·25 per cent. as against 12·22 per cent. in mosaic-free plots. Definite observations on the bionomics of *Scirpophaga nivella* Fb. have shown that the borer hibernates in cane as larvæ till the third week of February, that pupation begins in the last week of February, and that the first moth emerges about the 28th February. The other important sugarcane pest under observation is *Pyrilla* spp. the incidence of which was noticed to increase by the middle of June when oviposition on a large scale took place.

Hand-picking, trenching and poisoned baits were adopted against *Agrotis ypsilon* Rott which did considerable damage to peas, mustard and linseed crops. When the infested fields were flooded, the caterpillars were brought up to the surface and picked off by birds which came down in swarms. Light spraying with naphthaline emulsion had a considerable effect on unrestricted oviposition of the pea stem *Agromyzid* which infested experimental plots. The incidence of *Myzus persicae* Sulz. on peach and of *Papilio demoleus* Linn. on *Citrus* spp. was successfully controlled by spraying with nicotine sulphate and lead arsenate respectively.

The probable transmission of the crinkly leaf disease and the yellow mosaic disease of tobacco by insect agency is being investigated, and various stomach and contact poisons are being tried for their relative efficacy against cockroaches.

The life-histories of about 40 insects were studied partly or fully, and a survey of the various insects causing damage in the fruit orchards of British Baluchistan was continued.

THE SPREAD OF IMPROVED VARIETIES OF CROPS

During the year under report, the Botanical Section and its Sub-station at Karnal and the Agricultural Section at Pusa distributed to Provincial Departments of Agriculture and to private growers the following quantities of seed of improved varieties :—

55,037 lb. of wheat
42,650 lb. of oats
3,168 lb. of barley
1,128 lb. of paddy
12,001 lb. of gram
1,298 lb. of pigeon-pea
778 lb. of linseed
165 lb. of <i>ganja</i> (Indian hemp)
23 lb. of tobacco
777,894 lb. of sugarcane setts
and 3,104 lb. of maize and miscellaneous.

The Sugarcane Breeding Station at Coimbatore supplied the Sugarcane Research Station at Shahjahanpur with 5,000 cane seedlings

with a view to exploring the possibilities of selecting and rejecting new seedlings in sub-tropical India even in the nursery stage. In addition, over 200 packets of seed canes were sent to about 30 places in India. The above figures by no means represent the spread during the year of the improved varieties tried at Pusa and Coimbatore, for the distribution of improved seeds is mainly carried out by local Departments of Agriculture who obtain yearly relatively small quantities of seed from Pusa and multiply them for distribution to ryots. In fact, the actual areas under improved varieties of wheat and sugarcane run into millions of acres.

AGRICULTURAL MACHINERY

Further experience with the Lanz Bulldog 15/30 H. P. tractor, which is of the semi-Diesel type, has shown that the installation of a cylinder liner in this model is an essential. The Marshall semi-Diesel 15/30 H. P. tractor purchased in 1932 has been exchanged with the new 18/30 H. P. model in which the fuel pump cam and sleeve are solid which is a distinct improvement. A fresh addition to the test fleet is a 9/18 H. P. Farmall row crop tractor in which the ploughing capacity is subordinated in design and construction to row crop work : it is a tractor which can intercultivate and ridge up as well as plough two furrows, while a tractor primarily constructed to plough cannot do row crop work at all. It appears to be an exceptionally efficient design which will be of great advantage in all parts where the cost of labour is high.

A hand winnower was designed and completed to work with the bullock-gear thresher suitable for Indian conditions mentioned in last year's report. The complete outfit consisting of the thresher, the winnower and the bullock gear is being marketed by a well-known engineering firm for Rs. 1,000.

The Dunlop pneumatic equipment for bullock carts was fully tested throughout the season under loads of sugarcane varying from 40 to 60 maunds (3,280 lb. to 4,920 lb.) carted either to the railway station (6 miles) or direct to the mill (14 miles). It stood up to every test excellently and showed no sign of any wear and tear and reduced carting costs to a marked extent. Further tests are in progress to test the farm life of the tyres.

CATTLE BREEDING AND DAIRYING

Pusa.—The new system of feeding and handling the Sahiwal pedigree herd introduced two years ago continued to function successfully : though the milch herd numbers were reduced from 80 to 69, the total milk yield rose from 2,99,990 lb. to 3,00,690 lb., and the average yield per cow per day increased from 17·9 lb. to 18·7 lb., the highest average yield of 22·0 lb. being recorded in April 1934. The "in milk" percentage of the herd stood at 66·2 after excluding

cows kept for breeding alone and 'draft' cows put aside for sale. A notable increase in the milk yield of heifers has occurred, the average figures for the last four months of the year under report being higher than those for the corresponding period of any of the previous nine years. The experiments in early maturity are giving equally encouraging results. One bull, which started service at 18 months, is of full average size and weight at the age of three years, and his calves also show no signs of deterioration. Despite their early age heifers going to bull are of full average weight.

Karnal.—Breeding work with two indigenous breeds, viz., Haryana and Thar Parkar is being continued. Since 1923-24 when the foundation herds of these breeds were purchased, the average milk yield in both cases has increased by 50 per cent. and the lactation period has been extended by about 25 per cent. Systematic recording of fat percentage in the milk of individual cows has shown that Haryanas on an average yield 0.72 lb. fat as against 0.57 lb. given by Thar Parkars.

Bangalore.—In pursuance of the policy laid down by Government, the number of cattle with European blood is being gradually reduced and breeding work is concentrated on Scindi and Gir cattle. A systematic investigation of the method of making Surti cheese has been started and valuable data is being obtained with a view to standardizing the process.

ANIMAL NUTRITION

Another year's work by the Physiological Chemist on the influence of high and low protein feeding on milk production has shown that as cows on a low protein ration eat more fodder, the total food consumption is almost identical in both cases but that corresponding to the higher starch equivalent of a high protein ration there is a higher milk yield. Further tests are being carried out to confirm this question of milk yield and also to see how the cows tolerate the high protein level. Experiments are also in progress to determine the value for milk production of rations in which molasses replace weight for weight some of the usual concentrates.

As in previous year, various Indian coarse fodders were tested for digestibility, the main object being to determine the effect of advancing maturity upon composition and digestibility. It may now be taken as established that there is a relationship between the digestibility and protein content of fodders and that the digestion co-efficients for protein and carbohydrates increase as the protein content rises. A noteworthy feature of these trials was the high protein content and the high digestibility of Rhodes grass as compared with spear grass grown on similar land.

In view of the desirability of encouraging the production and utilization of legume hays, an investigation into the best method of preparing them, their digestibility and their effect on the nitrogen

balance is being carried on. There is practically no change in the chemical composition and only a slight diminution in the digestibility when lucerne is converted into hay, but even under ideal conditions of conversion the loss of dry matter, mainly through fermentation, is as much as 13 per cent.

The investigation the object of which is to determine comparative values of the mineral composition of grasses grown on selected typical soils in various parts of India, is beginning to yield important information. It has been noticed at Bangalore that of the three pure species of grass grown there, viz., *Andropogon contortus*, *Cynodon dactylon* and *Pennisetum cenchroides*, *Andropogon contortus* gives in very deeply and thoroughly cultivated land a product abnormally rich in minerals, that *Cynodon dactylon* has a tendency to contain more lime than the other species which definitely exceeds phosphoric acid and that *Pennisetum cenchroides* contains less lime than *Cynodon dactylon* and at times seems to contain more phosphoric acid than lime which is unusual.

The experiment in which the Physiological Chemist showed that inorganic sulphate is assimilated by cattle has been extended to sheep. These animals too have been found to make use of inorganic sulphate to an appreciable extent.

In addition, various physiological studies are on hand, for which reference should be made to the Report of the Physiological Chemist.

At Pusa, feeding experiments are in progress to find out the exact food values of berseem hay and oats hay which have proved excellent dry fodders in maintaining a suitable ration for the dairy herd from April to June.

III. GENERAL ADMINISTRATION

Charge.—Dr. W. McRae, Director, was granted a year's extension of service from 26th May 1933. On his appointment as Offg. Agricultural Expert to the Imperial Council of Agricultural Research, Dr. F. J. F. Shaw officiated as Director from 28th April 1934 to 22nd June 1934, and was appointed substantively to the post from 23rd June 1934, when Dr. McRae retired from the Indian Agricultural Service having been granted a further extension of service for 28 days from 26th May 1934 and 22 days' leave on average pay from 1st June 1934 preparatory to retirement.

Staff.—Changes owing to absences on leave, etc :—

Mycological Section.—Dr. M. Mitra in charge from 28th April 1934 vice Dr. McRae on other duty followed by retirement from the Indian Agricultural Service on 23rd June 1934.

Physiological Chemist's Section.—Mr. A. V. Iyer upto 22nd November 1933 vice Mr. F. J. Warth on leave.

Sugarcane Station, Coimbatore.—Mr. N. L. Dutt in charge for one month from 6th September 1933 *vice* Rao Bahadur T. S. Venkataraman on leave.

Training.—During the year under report, four post-graduate students completed their training at Pusa : one—a two-year course in Botany and three—a one-year course in farm organization, farm management and general farm engineering. One student in Chemistry left for taking up an appointment without completing his course. Twenty-four students applied for admission to the new session beginning on the 1st November 1933, of whom 11 were nominees of either Provincial Selection Committees or Provincial Directors of Agriculture. Eight applicants were selected for admission : four in Botany, two in Chemistry, one in Entomology and one in General Agriculture. The number of post-graduates under training at the close of the year under report were as follows :

Economic Botany and Plant Breeding	9
Sugarcane Breeding and Cultivation	3
Agricultural Chemistry	3
Entomology	2

Three post-graduate students were admitted to the fifteen-month post graduate course in Animal Husbandry, Animal nutrition and Dairying beginning on 2nd January 1934 : this course is divided between Bangalore, Karnal and Pusa.

Nineteen students sat for the Indian Dairy Diploma examination held at Bangalore in the last week of November 1933, of whom 15 qualified for the award of the Diploma. A new class with 21 students was opened in October 1933.

A number of students and post-graduate workers were also admitted for periods of work or training in various Sections of the Institute. Of the 15 British soldiers admitted to the Bangalore Dairy Farm for a six-month vocational course in practical dairying, only 11 remained for the full period : four left after four months as they were sent out of India. Another batch of 15 soldiers was admitted on 2nd February 1934 for a similar course. A special course in the flue-curing of tobacco organized at Pusa, which was attended by nine students deputed by seven Provincial Departments of Agriculture, was cut short owing to a severe hailstorm ruining the tobacco crop and the earthquake of 15th January 1934 damaging the flue-curing barn.

Library.—Publications received in exchange numbered 1,250, while 367 were purchased. Of the 1,667 publications issued on loan 154 were to scientific workers in the provinces and universities.

Hospital.—Medical relief was afforded to 325 in-patients and 8,400 out-patients in 1933. The total number of operations performed was 260. The health of the residents of the Estate was satisfactory and there was no serious outbreak of any epidemic disease.

IV. ACCOUNTS

The total expenditure for the Institute and its out-stations during the financial year ending 31st March 1934 amounted to Rs. 8,89,676 as against Rs. 9,09,599 for the previous year.

Name of Establishment.	Expenditure.*
	Rs.
General expenditure of the Institute including the Office of the Director, Power and Gas plants, the Medical and Estate Establishments	1,94,165
Agricultural Section	1,33,156
Botanical Section	53,579
Chemical Section	34,946
Mycological Section	26,774
Entomological Section	53,867
Bacteriological Section	35,935
Imperial Dairy Expert	29,354
Bangalore Dairy	1,10,830
Wellington Dairy	37,276
Karnal Farm	61,839
Physiological Chemist's Section	40,568
Sugarcane Station, Coimbatore	77,387
	8,89,676

Provisional figures.

The cost of the Botanical and Sugarcane Sub-stations at Karnal and the Scheme for research on Mosaic and other diseases of sugarcane amounting to Rs. 21,414, Rs. 8,358, and Rs. 20,319, respectively, was met from funds from the Imperial Council of Agricultural Research.

The receipts of the Institute and its out-stations amounted to Rs. 2,24,515† as shown below :—

	Sale of dairy produce	Sale of Farm produce	Fees from Students	Miscellaneous Receipt	Total
Pusa Institute	11,659	10,717	4,262	9,680	36,318
Bangalore Dairy	77,046	162	3,485	11,732	92,425
Wellington Dairy	42,601	..	..	1,841	44,442
Karnal Farm	13,006	24,768	..	5,562	43,336
Coimbatore Sugarcane Station . . . . .	..	..	..	7,994	7,994
Total . . . . .	..	..	..	..	2,24,515

The figures are provisional:

REPORT OF THE IMPERIAL AGRICULTURIST

[WYNNE SAYER, B.A., DIP. AGRI. (CANTAB.)]

I. CHARGE

I held charge of the Agricultural Section throughout the year.

Mr. Arjun Singh, Assistant Agriculturist was on leave on average pay for two months and sixteen days from the 7th July, 1933.

Mr. P. V. Krishna Iyer, M.A., was appointed as Statistician with effect from the afternoon of the 11th November, 1933.

II. TRAINING OF POST-GRADUATE STUDENTS

Messrs. Puran Singh, L. Ag., Abdul Rahim Khan, B.Sc. (Agri.) and J. D. Hill, Post-graduate students completed one year's training in general agriculture and farm organisation in the month of November, 1933. Mr. Imdad Ali Khan, B.Sc. (Agri.), Sugarcane Research Student, proceeded to Coimbatore in the same month to do a further year's training in sugarcane breeding under the Sugarcane Expert.

After completing one year's training at Coimbatore, Messrs. Khushi Mohamed, B.Sc. (Agri.) and Harbans Singh, B.Sc. (Agri.), joined this Section in November 1933, for their second year's study in sugarcane research. Mr. R. K. Tandon, B.Sc. (Agri.), M.Sc. was taken in for one year's training in farm organisation and general agriculture from the 2nd November, 1933.

III. SEASON

The total rainfall during the year from the 1st June 1933, to the 30th May, 1934, amounted to 51·70 inches against 37·16 inches in the corresponding period of the previous year. Exceptionally heavy rainfall (20 inches) in the month of July, 1933, accompanied by a flood affected the maize crop, the yield of which was very poor. The rain and flood in the last week of October put back the *rabi* sowings, especially berseem.

Earthquake.—A severe shock of earthquake occurred on Monday, January 15, 1934, at 2-13 P.M. accompanied by cracking of the earth and the discharge of water and sand from the fissures. The structure of almost all buildings was cracked. Two *bhusa* barns of the farm collapsed.

IV. SEED SUPPLY

The following seeds of improved varieties of crops were distributed :—

Variety	Quantity supplied lb.	Variety	Quantity supplied lb.
Wheat P. 12 . . .	6,097·0	Gram T. 17 . . .	2,633·1
„ P. 52 . . .	1,661·2	„ T. 25 . . .	966·9
„ P. 101 . . .	1,241·6	„ T. 58 . . .	246·9
„ P. 111 . . .	1,188·0	Lentil T. III—86 .	658·3
„ P. 4 . . .	658·3	Soybean yellow . .	66·8
Barley T. 21 . . .	1,647·0	Soybean black . .	25·7
Pea T. 14-1 . . .	205·7	Soybean chocolate .	108·0
„ No. 1 . . .	41·1	Cowpeas . . .	25·7
„ No. 2 . . .	41·1	Arhar T. 51 . . .	374·4
„ No. 4 . . .	8·2	„ T. 15 . . .	164·6
Maize No. 1 . . .	433·0	„ T. 24 . . .	205·7
„ No. 2 . . .	302·4	„ T. 80 . . .	82·3
„ No. 3 . . .	481·4	Sugarcane Co. 285 .	25,920·1
Meth . . .	313·7	„ Co. 281 . . .	271,672·3
Oats hybrid C . .	987·4	„ Co. 299 . . .	86,373·8
Oats hybrid J . .	165·6	„ Co. 331 . . .	326,360·6
„ B. S. I . . .	39,498·3	„ Co. 214 . . .	44,290·5
„ B. S. II . . .	1,152·0	„ Co. 213 . . .	21,080·6
		„ Co. 343 . . .	1,296·0

V. CROP STATEMENT

The following statement gives the principal crops grown on the farm and yields obtained.

Crop	Variety	Area in acres	Yield in Mds.	
			Total	Average per acre
Maize corn . . .	..	57·56	464—8—12	8·07
Maize—green fodder .	..	170·51	22,863—36—0	134·09
Wheat . . .	P. 4	11·10	71—28·8	6·46
„ . . .	P. 12	16·22	254—0—4	15·66
„ . . .	P. 52	38·98	407—22—0	10·45
„ . . .	P. 111	11·21	122—25—14	10·94

Crop	Variety	Area in acres	Yield in Mds.	
			Total	Average per acre
Wheat	Other varieties	5·35	62—18—0	11·67
Barley	T 21	10·57	149—7—8	14·11
<i>Arhar (Cajanus indicus)</i> .	A 4	11·25	69—21—4	6·17
„	T 15	10·00	99—11—12	9·93.
„	T 24	10·00	81—15—12	8·14
„	T 51	7·00	41—31—8	5·97
„	T 80	10·00	98—13—8	9·83
Pea	P. F. 1	2·68	30—8—8	11·27
„	P. F. 2	3·38	34—20—0	10·20
„	P. F. 3	4·17	29—19—0	7·07
„	P. F. 4	1·07	10—15—8	9·72
Gram	T 58	4·58	30—7—0	6·58
„	T 17	26·00	160—30—0	6·18
„	T 25	5·00	34—16—12	6·88
„	P. F. 3	1·27	14—26—0	11·53
Oats grain . . .	B. S. I	128·17	2,193—1—10	17·11
„	B. S. II	10·17	176—14—8	17·34
„ hay	B. S. I	91·50	5,288—33—0	57·80
Berseem—green fodder (Pusa Dhab area).	..	71·20	18,796—23—0	264·00
Ditto (New Area)	..	32·24	14,771—30—0	458·18

VI. EXPERIMENTAL WORK

The following experiments were conducted by the Agricultural Section during the year under report :—

1. Manurial Experiments—

(a) Permanent manurial and rotation experiments, Punjab field, Block C. & D.

(b) New manurial and rotation experiments in Randomised blocks conducted on the lines of the above experiment, Punjab field, Block A.

(c) Green-manuring experiments with sann-hemp, *guar*, (*Cyamopsis psoralioides*), *meth* (*Phaseolus aconitifolius*), Soybean cowpea and velvet-bean on wheat, Punjab field, Block B.

(d) Effects of sulphate of potash and muriate of potash on berseem seed production, Simri Dhab.

(e) Manurial experiments with rape-cake and superphosphate on sugarcane : different doses of nitrogen with a constant amount of phosphoric acid, Old Jhilli.

(f) Manurial experiments with superphosphate and rape-cake on sugarcane : different doses of phosphoric acid with a constant amount of nitrogen, Old Jhilli.

(g) Manurial experiments with sulphate of potash on sugarcane : different doses of potash with standard manure, Janghat field.

(h) Sugarcane manurial and rotation experiments, Harpur Jhilli.

(i) Manurial experiments with organic and inorganic fertilisers on sugarcane, New Area, Pusa A.

(j) Effect of farmyard manure and silt on the tonnage yield of sugarcane, New Area, Pusa B.

2. Varietal yield trials—

(a) Maize for fodder, Punjab field, Block B.

(b) Maize for corn, Punjab field, Block B.

(c) Soybean for fodder, Punjab field, Block B.

(d) Soybean for seed, Punjab field, Block D.

(e) Gram, Punjab field, Block B.

(f) Field-pea (*Pisum arvense*), Punjab field, Block B.

(g) Pea (*Pisum sativum*), Punjab field, Block B.

(h) Barley, North Pangarbi field.

(i) Oats, North Pangarbi field.

(j) Wheat, North Pangarbi field.

(k) Wheat, Brickfield No. II.

(l) Sugarcane, Co.'s 214, 299 and 313, Old Jhilli.

(m) Sugarcane, Co.'s 210, 213 and 331, Old Jhilli.

(n) Sugarcane, Co.'s 210 and 213, New Area, Pusa A.

3. Experiments for other Sections of the Institute—

(a) Manurial experiments with organic and inorganic fertilisers on sugarcane for the Imperial Agricultural Chemist, New Area, Pusa A.

(b) Green manuring experiments for the Bacteriologist : maize and wheat, sann-hemp and wheat, *urid* (*Phaseolus Mungo* var. *Roxburghii*) and wheat, sann-hemp tops and wheat, North Nepali field.

(c) Green-manuring experiments for the Bacteriologist : sann-hemp, sann-hemp tops, *urid* and soybean on wheat, Nepali field.

(d) Green-manuring experiments for the Bacteriologist : sann-hemp and Mexican sunflower on wheat, Nepali field.

(e) Experiments on the yellowing of sugarcane leaves for the Bacteriologist, New Area, Pusa A.

(f) Preliminary experiments with oats for yield trial with *rahar* for the Imperial Economic Botanist, Chandman paddock.

(g) Mosaic tonnage experiments with Co. 213 for the Imperial Mycologist : mosaic *versus* mosaic free cane, Silk House Area.

4. *Miscellaneous experiments—*

(a) Experiments to see the effect of speed of tractor-drawn implements on soil tilth and crop yield, Brickfield, No. II.

(b) Effect of formalin treatment on oats against smut, Brickfield, No. II.

(c) Spacing experiments with maize for fodder, Punjab field, Block B.

(d) Spacing experiments with maize for corn, Punjab field, Block B.

(e) Complex experiments with the cultivation of sugarcane : spacing and arrangement of setts at planting, New Area, Pusa B.

(f) Sugarcane cutting experiments with Co. 210 for ascertaining the correct size of experimental plots, New Area, Pusa A.

(g) Interlocking experiments with 'lodging' sugarcane varieties, New Area, Pusa A.

(h) Trashing of early ripening canes for seed with Co.'s 214, 299, 281 and 313, Old Jhilli and Janghat fields.

(i) Germination study in trashed and fresh canes, New Area, Dholi block.

VII. RESULTS OF FIELD AND OTHER EXPERIMENTS

1. MANURIAL EXPERIMENTS

(i) *Permanent manurial and rotation experiments.*—These experiments were continued as before.

The yields in various plots during the year were as follows :

Results of permanent manurial and rotation experiments for the year 1933-34.

Treatment	A SERIES		B SERIES		
	KHARIF 1933	RABI 1933-34	KHARIF 1933	RABI 1933-34	
	Maize grain per acre	Wheat grain per acre	Maize grain per acre	Peas grain per acre	Barley grain per acre
	lb.	lb.	lb.	lb.	lb.
GROUP I					
1. No manure (Check plot No. 1).	411	652	460	378	..
2. Farmyard manure @ 4,000 lb. per acre.	591	1,068	797	571	..
3. Farmyard manure @ 8,000 lb. per acre.	690	1,320	944	854	..
4. Farmyard manure @ 4,000 lb. per acre <i>plus</i> rape-cake to supply 20 lb. nitrogen per acre at the time of last inter-culture.	928	1,280	1,068	761	..
5. Rape-cake @ 40 lb. nitrogen per acre, half to be applied just before <i>kharif</i> sowing and half to be applied at last inter-culture.	842	956	961	558	.
GROUP II					
6. Sulphate of ammonia @ 40 lb. nitrogen per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>rahar</i> is sown, it is to be applied in one dose in <i>kharif</i> .	460	516	468	312	..
7. Sulphate of potash @ 50 lb. K_2O per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> crop is sown, it is to be applied in one dose in <i>kharif</i> .	370	448	431	353	..
8. Superphosphate @ 80 lb. P_2O_5 per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> is sown, it is to be applied in one dose in <i>kharif</i> .	632	816	575	813	..

Treatment	A SERIES		B SERIES		
	KHARIF 1933	RABI 1933-34	KHARIF 1933	RABI 1933-34	
	Maize grain per acre	Wheat grain per acre	Maize grain per acre	Peas grain per acre	Barley grain per acre
GROUP II— <i>contd.</i>	lb.	lb.	lb.	lb.	lb.
9. Sulphate of potash @ 50 lb. K_2O per acre and superphosphate @ 80 lb. P_2O_5 per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> is sown, they are to be applied in one dose in <i>kharif</i> .	640	1,124	640	895	..
10. Sulphate of ammonia @ 40 lb. nitrogen, sulphate of potash @ 50 lb. K_2O and superphosphate @ 80 lb. P_2O_5 per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> is sown, they are to be applied in one dose in <i>kharif</i> .	673	984	682	755	..
11. Sulphate of ammonia @ 40 lb. nitrogen and superphosphate @ 80 lb. P_2O_5 per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> is sown, they are to be applied in one dose in <i>kharif</i> .	501	836	682	731	..
13. No manure (Check plot No. 2)	411	412	378	246	..
14. Sulphate of ammonia @ 40 lb. nitrogen per acre, sulphate of potash @ 50 lb. K_2O per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> is sown, they are to be applied in one dose in <i>kharif</i> .	476	476	468	172	..
GROUP III					
12. Green manure in conjunction with a purely cereal rotation.	G.M.	552	G.M.	..	661
15. Effect of green manure and leguminous crop in the rotation.	G.M.	976	698	374	..
16. As for plot No. 15, but with an additional application of superphosphate @ 80 lb. P_2O_5 per acre to be applied with green manure only.	G.M.	2,060	1,047	1,076	..
17. No leguminous crop and no green manure.	550	716	468	..	361
18. No manure (Check plot No. 3) .	595	528	567	263	..

(ii) *The new manurial and rotation experiments*, full details of which have been given in the last year's report, were continued this year in the Punjab field, Block A. The following are the results of the experiments:—

Treatment per acre	MEAN YIELD PER PLOT	
	Maize No. 1 lb.	Pea No. 1 lb.
A. No manure	4·127	12·250
B. Farmyard manure* @ 8,000 lb.	6·871	21·500
C. Rape-cake @ 40 lb. N	14·050	18·125
D. Amm. sulphate @ 40 lb. N	5·695	11·475
E. Potassium sulphate @ 50 lb. K ₂ O	4·583	13·375
F. Superphosphate @ 80 lb. P ₂ O ₅	4·521	21·025
G. Pot. sulphate @ 50 lb. K ₂ O & superphosphate @ 80 lb. P ₂ O ₅	3·302	20·475
H. Amm. sulphate @ 40 lb. N, superphosphate @ 80 lb. P ₂ O ₅ & Pot. sulphate @ 50 lb. K ₂ O	6·396	18·075
I. Amm. sulphate @ 40 lb. N and superphosphate @ 80 lb. P ₂ O ₅	7·858	20·500
J. Amm. sulphate @ 40 lb. N and pot. sulphate 50 lb. K ₂ O	5·833	10·875

*Composition of farmyard manure :—N—0·61% ; P₂O₅—0·40 % ; K₂O—0·78%

Fisher's 'z' test was applied and the general effect of treatments was found to be significant at the one per cent. level. Fisher's 't' test was also applied and the results were significant as shown below:

Maize

Critical difference = 2·669 (P=·01)
 = 2·013 (P=·05)
 C>I=B>H>J=D=E=F=A=G

Pea

Critical difference = 5·819 (P=·01)
 = 4·390 (P=·05)
 B=F=I=G=C>H>A=D=E=J

(iii) *Green manuring experiments in the Punjab field, Block B.*—The experiment was started this year with a view to study the effect

of various leguminous crops as green manure on the yields of wheat grown in *rabi*. The six treatments were put in a 6×6 Latin Square and the following results were obtained :—

Treatment	Mean yield per plot in lb. of wheat P. 52 (Area of each plot = 0.03 acre)	' z ' test	Critical difference
T 1—Sann-hemp . . .	36.46	Not significant	7.856 (P = .05)
T 2—Cowpea . . .	38.00		
T 3—Guar . . .	36.25		
T 4—Meth . . .	34.71		
T 5—Soybean . . .	28.58		
T 6—Velvetbean . . .	36.50		

Conclusions :— $T_1 = T_2 = T_6 > T_5$

(iv) *Effect of sulphate of potash and muriate of potash on berseem seed production.*—The object with which this experiment was started last year was not attained during the year under report. Besides the usual manuring programme, detailed in last year's report, the crop was also put on high land without any treatment and grown under controlled irrigation. This method of growing the crop for seed has shown some success, and it is expected that better results will be obtained next year with further control of irrigation.

(v) *Manurial Experiments with Rape-cake and superphosphate on sugarcane Co. 213 in Old Jhilli.*—The experiments were laid out in Randomised Blocks with six replications for each treatment. The manures were applied at the time of planting sugarcane, and the amount of phosphoric acid in rape-cake was deducted from the main dressing of superphosphate.

The results may be summarized as follows :—

Treatment per acre	Sucrose per cent. (Feb.)	Tonnage		
		Mean yield per plot in lb. (Area of each plot = 0.05 ac.)	" z " test	" t " test
T 1—No manure . . .	15.94	3650.00	Not significant	Not significant
T 2—40 lb. N + 50 lb. P_2O_5	14.95	3922.00		
T 3—60 lb. N + 50 lb. P_2O_5	14.49	3927.00		
T 4—80 lb. N + 50 lb. P_2O_5	15.69	3825.25		

Treatment per acre	Sucrose per cent. (March)	Mean yield per plot in lb. (Area of each plot = 0.05 acre)	"z" test	Critical difference
T 1—No manure	17.56	2760.4	Significant at the 1% level	432.83 (P = .01)
T 2—50 lb. P_2O_5 + 40 lb. N	16.64	3282.0		
T 3—75 lb. P_2O_5 + 40 lb. N	16.31	3348.7		
T 4—100 lb. P_2O_5 + 40 lb. N	16.36	3305.4		

Conclusions : - $T_2 = T_3 = T_4 > T_1$

(vi) *Sugarcane manurial and rotation experiments with Co 310 in Harpur Jhilli.*—The object of this experiment is to maintain the land in best possible condition for a close cane rotation such as cane-fallow—cane. The treatments were put in double Latin Squares with ten replications for each. The experimental area was under cane during 1931-32. The treatments per acre were :—

A. Fallow in *kharif* and 14 tons farmyard manure (Dowlatpore dressing) at the end of monsoon.

B. Fallow in *kharif* and complete minerals (40 lb. N as ammonium sulphate, 50 lb. P_2O_5 as superphosphate and 40 lb. K_2O as potassium sulphate) applied at the time of planting cane.

C. Sann-hemp sown in *kharif* and ploughed in after eight weeks with 50 lb. P_2O_5 as superphosphate. 40 lb. N as rape-cake applied at the time of planting cane.

D. Sann-hemp sown in *kharif* and ploughed in after eight weeks. Complete minerals (as in treatment B) applied at the time of planting cane.

E. Fallow in *kharif* and standard manure (40 lb. N as rape-cake and 50 lb. P_2O_5 as superphosphate) applied at the time of planting cane.

The results of the experiment are given below :—

Treatment	Tonnage			
	Sucrose per cent. (Feb.)	Mean yield per plot in lb. (Area of each plot = 0.045 acre)	"z" test	Critical difference
A	{ 14.70 14.05	3185.7	Significant at the 1% level	171.36 (P = .01)
B	{ 15.63 15.91	2698.7		127.02 (P = .05)
C	{ 14.98 15.19	2847.4		
D	{ 15.35 15.70	2737.7		
E	{ 15.18 15.35	2695.3		

Conclusions :— $A > C > B = D = E$

The experiment will be repeated in 1935-36.

(vii) *Manurial experiments with organic and inorganic fertilisers on sugarcane Co. 210 in the New Area, Pusa A.*—The experiment was laid out in Latin Square with six replications for each treatment. The different kinds of manures applied per acre were as follows :—

T1—No manure.

T2—10 tons farmyard manure applied at the end of monsoon.

T3—20 tons farmyard manure applied at the end of monsoon.

T4—Green manure (sann-hemp) in *kharif* and complete minerals (40 lb. N as amm. sulphate, 40 lb. K_2O as pot. sulphate and 50 lb. P_2O_5 as superphosphate) applied at the time of planting cane.

T5—Complete minerals (as in T4) applied at the time of planting cane.

T6—Green manure (sann-hemp) in *kharif* with 50 lb. P_2O_5 as superphosphate.

It will be seen in the table given below that the dressing of 20 tons farmyard manure per acre has turned out to be the best, and this has further been confirmed by the results of the manurial experiment of Harpur Jhilli detailed before. The results of these two experiments indicate that farmyard manure (at the rate of 14 tons per acre) is the most suitable dressing for sugarcane crop in this tract.

Treatment	Sucrose per cent. (Decr.)	Tonnage		
		Mean yield per plot in lb. (Area of each plot = 0·022 acre)	" z " test	Critical difference
T1	15·47	724·0	Significant at the 1% level	219·32 (P=·01)
T2	14·89	1300·7		
T3	13·65	1667·2		
T4	14·59	1413·5		160·81 (P=·05)
T5	15·13	1110·2		
T6	15·15	1145·2		

Conclusions :—T3 > T1, T2, T4, T5 & T6 ; T4 > T1, T5 & T6 ;
T2 > T1 & T5 ; T6 > T1 ; T5 > T1

(viii) *Effect of farmyard manure and silt on the tonnage yields of sugarcane Co.'s 210, 303, 313 and 331.*—A preliminary experiment as

to the possibility of replacing farmyard manure, which at times cannot be had in large quantities, by some equally good and easily procurable substitute, such as river silt, was carried out in the New Area, Pusa B.

The results of the chemical analysis of silt and that of the experiment are given below :—

CHEMICAL ANALYSIS OF SILT

Organic nitrogen—0·036% on air dry soil.

Phosphoric acid (P_2O_5)—0·048% on air dry soil.

Potash (K_2O)—0·921 % on air dry soil.

The silt was poor, both in organic nitrogen and phosphoric acid.

Tonnage yield per acre

Treatment	Co. 210	Co. 303	Co. 313	Co. 331
	Mds.	Mds.	Mds.	Mds.
Silt @ 766 Mds. per acre . . .	649·15	660·97	650·96	866·54
Farmyard manure @ 367 Mds. per acre	614·66	786·48	568·05	1036·40

2. VARIETAL YIELD TRIALS

(i) *Yield trial with maize for fodder in the Punjab field, Block B.*—Four different varieties of maize were tried in double Latin squares with eight replications. The results of the experiment are summarized below :—

Variety	Mean yield per plot in lb. (Area of each plot=0·016 acre)	"z" test	Critical difference
P. F. 1	231·13	Significant at 5% level	33·537 (P = ·01)
P. F. 2	226·63		24·250 (P = ·05)
P. F. 3	221·13		
Local	194·75		

Conclusions :—PF1=PF2=PF3 > Local

(ii) *Yield trial with maize for corn in the Punjab field, Block B.*—The layout of the experiment was a double Latin square with eight replications for each variety. It will be seen from the results given below that the differences between the varieties are not statistically significant.

Variety	Mean yield per plot in lb. (Area of each plot = 0·016 acre)	'z' test	't' test
P. F. 1	12·74	Not significant	Not significant
P. F. 2	11·44		
P. F. 3	13·53		
Local	12·13		

(iii) *Yield trial with Soybean for fodder and seed in the Punjab field, Blocks B & D.*—Three varieties of soybean, evolved in the Agricultural Section were tried in a set of four Latin Squares for fodder and seed separately.

The results are given below :—

Variety	Mean yield per plot in lb. (Area of each plot = 0·019 acre)	'z' test	Critical difference
<i>Fodder—</i>			
No. 1—Yellow	227·3	Significant at the 1% level	18·28 (P = ·01)
No. 2—Chocolate . . .	264·5		
No. 3—Black	196·2		
(Area of each plot 0·015 acre)			
<i>Seed—</i>			
No. 1—Yellow	19·71	Significant at the 1% level	2·523 (P = ·01)
No. 2—Chocolate . . .	18·92		
No. 3—Black	15·20		

Conclusions :—Fodder No. 2 > No. 1 > No. 3

Seed No. 1 = No. 2 > No. 3 .

(iv) *Yield trial with gram in the Punjab field, Block B.*—The second year's trial with gram varieties was carried on during the year under report and below are the results :—

Variety	Mean yield per plot in lb. (Area of each plot = 0.022 acre)	'z' test	Critical difference
T. 17	11.72	Signifi- cant at the 1 % level	7.106 (P = .01)
T. 25	13.53		
T. 28	12.81		
T. 58	15.19		
P. F. 3	14.75		
P. F. 6	11.38		
P. F. 11	23.09		
P. F. 17	13.53		

Conclusions :—PF11 > T17 = T25 = T28 = T58 - PF3 = PF6
= PF17

(v) *Yield trial with field-pea (Pisum arvense) in the Punjab field, Block B.*—The experiment was laid out in a set of four Latin Squares with twelve replications for each variety. The results are shown below :—

Variety	Mean yield per plot in lb. (Area of each plot = 0.008 acre)	'z' test	Critical difference
P. F. 6	3.996	Signifi- cant at the 1 % level	0.905 (P = .05)
P. F. 7	3.505		
P. F. 8	4.563		

Conclusions :—P F 8 > P F 7

(vi) *Yield trial with pea (Pisum sativum) in the Punjab field, Block B.*—The trial was conducted in double Latin Squares with

eight replications for each variety. The following are the results of the experiments :—

Variety	Mean yield per plot in lb. (Area of each plot = 0.022 acre)	'z' test	Critical difference
P. F. 1 . . .	12.25	Not significant	4.481 (P = .05)
P. F. 2 . . .	15.69		
P. F. 3 . . .	17.63		
P. F. 4 . . .	14.00		

Conclusions :—P. F. 3 > P. F. 1.

(vii) *Yield trials with oats, barley and wheat in North Pangarbi field.*—Each of these crops was tried separately in double Latin Squares with eight replications. The results are summarized below :—

Variety	Mean yield per plot in lb. (Area of each plot = 0.009 acre)	'z' test	Critical difference
Oats B. S. 1 . . .	17.72	Significant at the 1 % level	1.980 (P = .01)
„ B. S. 2 . . .	17.56		1.432 (P = .05)
„ Hybrid C . . .	13.66		
„ „ J . . .	15.78		
	(Area of each plot = 0.008 acre)		
Barley T. 21 . . .	15.13	Do.	3.044 (P = .01)
„ C. 251 . . .	11.44		
„ Local 1 . . .	10.91		
„ „ 2 . . .	11.34		
Wheat P. 4. . . .	5.06	Do.	1.205 (P = .01)
„ P. 12 . . .	3.94		0.872 (P = .05)
„ P. 52 . . .	9.72		
„ Country . . .	5.50		

Conclusions :—

Oats B. S. 1 = B. S. 2 > H. J. > H. C

Barley T. 21 C. 251 = Local 1 = Local 2

Wheat P. 52 > Country = P. 4 > P. 12

(viii) *Yield trial with wheat in Brickfield No. 2: P. 52 versus Country.*—The experiment, on its third year of trial during the year under report, was concluded with the following results. The trial was carried out in Beaven's half-drill-strip method with twelve replications :

	lb.
Mean difference in favour of P. 52	9.67
Standard error	1.37
Critical difference ($P = .01$)	4.25

The result is highly significant at the one per cent level.

3. MISCELLANEOUS EXPERIMENTS

(i) *Experiments to see the effect of speed of tractor-drawn implements on soil tilth and crop yield in Brickfield No. 2.*—The second year's experiment was conducted on the lines detailed in the last year's report. The following implements were used in the two treatments :—

A.—Ploughing with five-furrow "Vice-Consul Share plough" at 4.5 inches on first speed (at 2.5 miles per hour) and harrowing twice with "Roderic Lean Disc Harrow" at the same speed.

B.—Ploughing with three-furrow "Consul Plough" at 4.5 inches on third speed (at five miles per hour) and harrowing twice with "Roderic Lean Disc Harrow" at the same speed.

The "Vickers" tractor, 23/40 H. P. was used for the work.

The tilth of soil in the two treatments was like the previous year's experiment. Oats B. S. 1 was grown in *rabi* and the results given below confirm the conclusions reached before :—

	lb.
Mean difference in favour of 5 miles speed	2.75
Standard error	5.48
Critical difference ($P = .05$)	12.64

(ii) *Effect of formalin treatment against smut in oats.*—An experiment was laid out on field-scale (Brickfield No. 2) to test the effectiveness of formalin treatment by dry method on oats infested with smut. The seeds were treated before sowing and were put against untreated seed in Beaven's half-drill-strip method with twelve replications. The ultimate size of plot was 117 ft. \times 14 ft. The results based on the final yields of oats grain were significant in favour of the treatment as shown below :—

	lb.
Mean difference in favour of formalin treatment	3.56
Standard error	1.24
Critical difference ($P = .05$)	2.74

(iii) *Spacing experiments with maize P. F. 1 for fodder and corn in the Punjab field, Block B.*—The experiments were laid out in double Latin Squares with eight replications for fodder and corn separately. The details of spacing and the results are given below :—

Spacing	Mean yield per plot in lb. (Area of each plot =0.016 acre)	' z ' test	' t ' test
<i>For Fodder</i>			
T. 1—9 inches . . .	232.63	Significant at 1 per cent. level	Critical difference 48.395 (P=.01) 34.995 (P=.05)
T. 2—12 „ . . .	180.63		
T. 3—15 „ . . .	189.75		
T. 4—18 „ . . .	168.50		
<i>For Corn</i>			
T. 1—9 inches . . .	12.44	Not significant	T. 1 > T. 2 = T. 3=T. 4 Not significant
T. 2—12 „ . . .	11.95		
T. 3—15 „ . . .	11.77		
T. 4—18 „ . . .	11.77		

(iv) *Complex experiments with cultivation of sugarcane Co. 210 in the New Area, Pusa B.*—The two variables in the experiment were (i) spacing : 3 ft. and 2½ ft. between rows and (ii) arrangement of setts at planting : eye to eye and end to end. The experiment was laid out in Randomised Blocks with six replications for each of the following treatments :

T. 1—2½ ft. spacing between rows, setts planted end to end.

T. 2—2½ ft. spacing between rows, setts planted eye to eye.

T. 3—3 ft. spacing between rows, setts planted end to end.

T. 4—3 ft. spacing between rows, setts planted eye to eye.

The statistical results of the experiment are given below :—

Treatment	Average tonnage yield per acre in lb.	'z' test	't' test
3 ft. spacing . . .	63957.5	} Not significant	Not significant
2½ ft. „ . . .	66945.0		
End to end . . .	65519.0	} Not significant	Not significant
Eye to eye . . .	65553.5		

(v) *Sugarcane cutting experiments with Co. 210 for ascertaining the correct size of experimental plot in the New Area, Pusa A.*—As most of the sugarcane experiments on the Farm are now laid down under Co. 213 or Co. 210, it was thought advisable to check the results obtained last year from the cutting experiments of Co. 213 conducted at Meghaul (Monghyr district) by a similar experiment with the other variety at Pusa. An area of four acres was put under Co. 210 and cut into 1/242 acre plots, each consisting of a single row of 3 ft. wide and 60 ft. in length. The data obtained from this experiment are being analysed statistically.

(vi) *Interlocking experiments with 'lodging' sugarcane varieties in the New Area, Pusa A.*—Co. 303 and Co. 322, the two 'lodging' varieties were grown interlocked with Co. 213 for testing their tonnage yields against Co.'s 213 and 331 in Randomised Blocks with six replications. The results of the experiment are given in the table below :—

Variety	Mean yield per plot in lb. (Area of each plot = 0.05 acre)	'z' test	Critical difference
A—Co. 213 + Co. 303.	2730.25	Significant at the 1 per cent. level	469.01 (P = .05)
B—Co. 213 + Co. 322	1946.92		648.61 (P = .01)
C—Co. 213	2382.00		
D—Co. 331	3320.83		

Conclusions :—D > A, B & C ; A > B

(vii) *Trashing of early ripening canes for seed with Co's. 214, 299, 281 and 313 in Old Jhilli and Janghat fields.*—The experiment was continued during the year under report and the damage caused by jackals and pigs to the standing crop was found to be less in comparison with the previous years' loss.

In germination study made on trashed and fresh canes under field conditions, it was found that percentage of germination was more in the case of trashed seed in all the varieties except Co. 299, where fresh seed gave better results.

An article dealing with the results of the above experiments will be published separately.

VIII. SUGARCANE VARIETAL WORK

The earthquake on January 15th caused a complete dislocation of mill work in the neighbourhood and in consequence it was only possible to put through one mill trial in the season, that on the early variety Co. 299, details of which have been published separately.

The impending trials of Co. 281 as a semi-irrigated cane in place of Co. 213 and Co. 331 as a heavy tonnage late ripening cane for April crushing had to be postponed indefinitely. A large quantity of cane cut out from experiments which required harvesting in February and March could not be disposed of, but every opportunity was taken to supply as much cane seed as possible to all concerns where railway facilities were still operative. As a result, it was possible to clear off a very large percentage of the early canes. The general tonnage canes were held over until the Samastipur mill re-opened on the 30th April when they were all taken off. This delay has given us an excellent opportunity of observing on a large scale the behaviour of cane allowed to stand over into May. It was noticeable that on heavy land and land in a four-year rotation, the cane stayed green into May despite the intense dry weather and absence of any hot weather rain. On three-year rotation land, however, the cane dried up very quickly, as the analyses clearly show.

The following varieties of cane were planted on a field scale during 1933-34 :—

Coimbatore canes : 210, 213, 214, 281, 285, 299, 303, 304, 313, 322, 331, 337, 339, 343 and 344.

The following varieties were under multiplication in the Nursery at New Area :

(a) Varieties imported from Coimbatore in 1931—Coimbatore canes : 347, 348, 350, Tuc. 393 and Tuc. 472 (Co. 338 was under observation in Sericulture area).

(b) Varieties imported from Coimbatore in 1932—Coimbatore canes : 381, 382, 384, 386, 387, 388, 393, 395, 396 and 397.

(c) Varieties imported from Coimbatore in 1933—Coimbatore canes : 360, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381*, 382*, 383, 384*, 385, 386*, 387, 388*, 389, 390, 391, 392, 393*, 394, 395*, 396*, 397*, 402, 408, 412, 413, 417 and 419.

The following varieties were rejected for 1934-35 planting—Coimbatore canes : 304, 322, 338, 350, Tuc. 393 and Tuc. 472.

All the above varieties were marked for rejection in 1933-34, but were finally rejected for 1934-35 planting.

Co. 322 lodges badly and can only be considered for estate planting, if interlocked with some other variety which has a good stand.

* Repeats.

Co. 338, Co. 350, Tuc. 393 and Tuc. 472 were discarded on account of bad agricultural habit.

Co. 338 was carefully observed to ascertain its value as an early cane, but its sucrose proved to be far below the early standard cane in October, and it was finally rejected.

Co. 388—10·73 } Sucrose in October.
Co. 299—12·41 }

Co. 304 proved to be below Co. 210 in tonnage and sucrose content and to have a higher fibre percentage.

Coimbatore canes : 367, 372, 376, 379, 380, 383, 385, 389, 390, 392 and 402. All failed completely in the first season's planting in the nursery. They will be repeated in 1935.

The following varieties were planted during February, 1934.

(i) Field scale trial against standard canes, Coimbatore canes : 210, 213, 214, 281*, 299, 303, 313, 331, 337, 339, 343, 344, 387, 388, 393, 395, 396 and 397.

(ii) Small scale trial under multiplication in nursery :

(a) 1931 Importations—Coimbatore canes : 347 and 348,

(b) 1932 Importations—Coimbatore canes : 381, 382, 384, and 386.

(c) 1933 Importations—Coimbatore canes : 360, 366, 368, 369, 370, 371, 373, 374, 375, 377, 378, 381, 382, 384, 386, 391, 394, 408, 412, 413, 417 and 419.

(d) 1934 Importations—Coimbatore canes : 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515 and 516.

The long list of importations show clearly that the problem of replacing our standard canes is still to seek. The majority of the canes received and tested do not show any improvement of that dual purpose nature which is essential, if a cane is to be welcomed to both grower and mill. Improvements in sucrose bringing in their train lower tonnage can never succeed in replacing a cane of Co. 213 class in a tract where tonnage alone is paid for, and the grower is free. The majority of the canes showing any promise ultimately fail on this point. Improvements on the tonnage side, such as Co. 285 find the mills adamant.

I do not consider that any marked improvement will ever be possible until the basis of value is radically revised. Till then the mill doing 9·5 on standard cane, and the grower being paid for the tonnage in Co. 213 will both feel they have the best deal possible.

Co. 213 and Co. 210 represent the nearest possible approach, in my opinion, to satisfying mill and grower. The monsoon variations and the hot weather period are such important factors in

* Semi-irrigated.

judging the real value of a cane, that it is impossible to justify the theory of taking any chance of replacing the above canes, which have made the industry, until absolute certainty exists, as to the value of the change. A change for the sake of a change is absurd and cannot be too strongly deprecated, and this should be carefully noted.

Results of field experiments and mill trial conducted with different varieties of sugarcane.

(i) *Mill trial of Co. 299.*—This cane was tested in a mill trial against Co. 214 and Co. 313 at the Samastipur Central Sugar Factory on the 19th November, 1933, by kind permission of Messrs. Begg, Sutherland & Co. Co. 214 which has been the standard early ripening cane to-date in the tract has a bad agricultural habit and poor tonnage yields. Recent trials conducted in the Agricultural Section had clearly proved Co. 299 to be an early cane of the class required for the district; its tonnage yields and laboratory analysis pointed to its being superior to Co. 214, the cane it was desired to replace. For the mill trial, an area of 1.64 acres was laid down in Randomised Blocks in Old Jhilli with six replications for each variety. The mill trial results have shown that a definite saving in raw material cost can be effected by the substitution of Co. 299 for Co. 214. The details of the results have been published separately.

(ii) *Tonnage yield trial with sugarcane Co. 210, Co. 213 and Co. 331 in Old Jhilli.*—The varieties were put in Randomised Blocks with six replications for each. The results are tabulated below :—

Variety	Mean yield per plot in lb. (Area of each plot = 0.05 acre)	'z' test	Critical difference
Co. 210 . . .	2995.33	Significant at the 1 per cent. level	501.68 ($P = .01$)
Co. 213 . . .	2889.75		
Co. 331 . . .	3815.00		

Conclusions :—Co. 331 > Co. 210 = Co. 213

(iii) *Tonnage yield trial with sugarcane Co. 210 and Co. 213 in the New Area, Pusa A.*—The experiment was laid out in Beaven's

half-drill-strip method with twelve replications for each variety. It will be seen that the result is not statistically significant.

	lb.
Mean difference in favour of Co.213	205.38
Standard error	126.75
Critical difference ($P=.05$)	276.19

It is important to notice that this experiment which has now been continued for some four years continues to give results which are not significant over a period of years. Co. 213 and Co. 210 are the standard canes of the tract and their selection for different areas must always be a question of local conditions, as it is impossible in face of the above figures, to give any definite ruling as to the tonnage superiority of one over the other.

Chemical analyses results and tonnage yields of principal varieties of sugarcane grown on the Pusa Farm during 1933-34.

Sugarcane variety	Field.	SUCROSE PER CENT. IN JUICE								Area in acres	Average Tonnage yield per acre (M.t.)
		Octr. 1933	Novr. 1933	Decr. 1933	Jany. 1934	Feby. 1934	March 1934	April 1934	May 1934		
Co. 210 .	H. Jhilli . New Area . Old Jhilli .	..	14.48	15.47	..	15.45	..	..	..	4.17 9.88 .30	699 719 728
Co. 213 .	Old Jhilli . Janghat . New Area .	..	..	11.56 13.38	..	..	17.56 17.43	18.05	18.35	5.68 .38 3.61	720 700 828
Co. 214 .	Old Jhilli . New Area .	..	15.99 13.28 16.61	18.23 17.56	18.36 17.08	19.62 19.19	..	..	..	.30 1.00	570 449
Co. 281 .	Janghat .	10.07	13.29	16.74	17.56	17.89	19.88	18.67	18.16	11.44	763
Co. 285 .	New Area .	..	..	..	..	..	..	..	..	1.70	856
Co. 299 .	Old Jhilli . New Area .	..	16.04 15.69 16.30	16.63 17.70 16.48	17.59 18.02	18.26 18.86	..	..	..	.30 1.52	604 460
Co. 303 .	New Area .	..	14.08	15.53	..	17.94	..	..	..	1.24	304
Co. 313 .	Old Jhilli . Janghat . New Area .	..	14.96 13.47 14.06	17.54 17.11	17.43 17.44	18.39 18.51	..	..	..	.30 .33 1.68	780 700 615

IX. MISCELLANEOUS CROPS GROWN FOR THE SECTION- AL OFFICERS OF THE INSTITUTE

(1) The following improved varieties of crops were grown for the Imperial Economic Botanist in the Agricultural Section for seed multiplication. The average yield per acre of each variety is given below :—

Crop	Field	Area in acres	OUTTURN OF GRAIN IN LB.	
			Actual	Per acre
Gram T 17	Gonhri	4.00	2972.00	743.00
" T 25	"	5.00	2832.10	566.42
" T 58	"	4.00	2236.10	559.03
Linseed T 124	Old Jhilli	1.50	501.90	334.60
" H 10	"	0.50	96.70	193.40
" H 55	"	0.50	67.90	135.80
" H 21	"	0.50	105.90	211.80
" H 68	"	0.50	52.40	104.80
" T 12	"	1.20	454.60	378.83
" T 121	"	1.00	323.00	323.00
Russian Flax	"	0.30	37.00	123.33
Lentil T 54	"	1.00	664.50	664.50
" T III-86	"	1.00	695.30	695.30
Oats Hybrid C	"	2.50	3072.80	1229.12
" B. S. II	"	2.50	3966.20	1586.48
" T III-86	"	1.50	2127.10	1418.07
Wheat P 12	Mysore	9.75	11157.70	1144.38
" P 52	"	9.75	13850.70	1420.58
" P 4	S. Pangarbi	11.00	5827.30	529.75
" P 111	Nepali	11.18	10072.60	900.95
" P 101	"	4.50	4260.40	946.75
Barley T 21	B. F. I(30 ac. block)	10.00	11898.60	1189.86
Arhar T 24	H. Jhilli (do.)	10.00	6697.50	669.75
" T 51	"	10.00	3438.50	343.85
" T 15	Chheonia	5.00	3676.10	735.22
" T 80	"	6.75	3761.00	557.19

(2) The following crops were grown in small plots for the Imperial Entomologist during the year under report :

Kharif—

Maize, *juar* (*Andropogon Sorghum*), *bajra* (*Pennisetum typhoid-eum*), *urid* (*Phaseolus Mungvar. Roxburghii*), *mung* (*Phaseolus radiatus*), castor, *til* (*Sesamum indicum*), sann-hemp, sweet potato, Java indigo, turmeric, ginger and sugarcane : Co. 213 and Co. 285 (October, 1932); Co. 213 (February, 1933); Co. 213 and Co. 285 (October, 1933); Co. 210, Co. 213, Co. 214 and Co. 313 (February, 1934).

Rabi—

Wheat, barley, peas, gram, mustard, linseed, lentil, chillies tobacco, potato and safflower.

X. MACHINERY

1. STEAM PLOUGHING TACKLE AND TRACTORS

The majority of the area outside the small field experiments was dealt with by tractors in the year under report. The steam tackle being only on the land for opening out at the end of the monsoon.

The collection of working data and cost figures for all the tractors under test was continued.

The International McCormick Deering 15/30 H. P. purchased in 1927 completed its seventh year and worked for 446·83 hours including belt work. It cost Rs. 1,191-6-9 in spare parts as against Rs. 453-15-5 expended last year. It is, therefore, now evident that it has worked to the economic limit, but further figures must be obtained to ascertain the time at which the breakdown period is reached.

It will be noticed that the cost of ploughing owing to the cost of the above spare parts went up to Rs. 5-15-1 per acre as against Rs. 4-13-5 per acre last year—a rise of approximately 23 per cent. on the major operation, and the curve may be expected to steepen rapidly from now onwards.

There was not, however, a marked increase in fuel consumption. The rise in the quantity of kerosene oil used being 2·69 gallons per hour against 2·56 gallons last year. It must, however, be clearly realised that this close economy in fuel consumption in an old tractor can only be obtained by a very drastic replacement policy in engine parts which, it is possible, may prove more costly in the end, but such information is necessary to complete the investigation.

The Vickers 23/40 H. P. kerosine oil tractor worked for its fifth year. It was sparingly used owing to its exceptionally high consumption of kerosine oil. This tractor is clearly demonstrating the fact that high horse power in this class of tractor produces a very steep rise in fuel consumption at an early stage which it is almost impossible to control under normal conditions. It was chiefly employed for exceptionally heavy or fast work.

Crude-oil tractors.—This branch of tractor working, which up to a short time ago, represented a complete innovation, is now of the greatest value, as the complete change over which has taken place among manufacturing firms recently has brought the crude-oil tractor to the forefront in the place of the kerosine oil models.

We are now furnished with invaluable working data for four years as a result of our forward policy with this class of tractor.

The Lanz Bulldog 15/30 H. P. tractor, which is of the semi-Diesel type worked steadily for 437·04 hours. This model has no cylinder liner, and owing to the fact that duplicate air cleaners were not standard at the beginning, the cylinder was badly worn by dust. A complete new cylinder and piston had therefore to be fitted, and this, worked with duplicate air cleaners, is now giving perfectly satisfactory service, but the installation of a cylinder liner in this model is essential, as the saving in the above case would have been very marked had it been possible to rectify the trouble by merely fitting a new liner.

The total cost of spare parts was Rs. 999-12-3 (including Rs. 755 for new cylinder) as against Rs. 231-13-5 last year. It may, however, be taken for granted that future replacements will follow a normal curve. The cost of ploughing per acre was Rs. 4-10-4 as against Rs. 3-1-5 last year, but the crude-oil consumption was only 1·5 gallons as against 1·59 gallons in the previous year.

The Marshall semi-Diesel 15, 30 H. P. tractor which was purchased in 1932 began to give considerable trouble after the first year's working due to the fuel pump cam slipping on sleeve and thereby making injection late. As this system has been entirely remodelled by the makers, the tractor was exchanged for the new 18/30 H. P. model on which the cam and sleeve are solid. This tractor is now working satisfactorily.

Changes of this class may be anticipated in the crude-oil tractor, as the design is by no means yet standardised and radical improvements may be looked for from year to year. This class of tractor has not been evolved like its kerosine oil prototype as a result of years of experiment and trial in motor car engines and has to obtain its data and improvements from field work. This point will come into greater prominence when the high speed vertical Diesels are in general use and many radical changes in design may be expected in course of time.

A distinct tendency to put a heavier tractor on the land is in evidence, partly because it enables the major work, ploughing to be done to greater depths and also because the H. P. capital cost is lessened, while the lengthening of service life is a further consideration, as the less liable a tractor is to overload, the longer will be its effective and economic life. Pneumatic treads are also coming in, and their effect on land is also in favour of the heavier types of tractor. In short the nearer the tractor can now approach to the steam engine in general, the better machine will it be for agricultural purposes.

A 9/18 H. P. "Farmall" row crop tractor was added to the test fleet in the year under report. This tractor embodies a completely

new principle in which the ploughing capacity is subordinated in design and construction to row crop work, i.e., it is a tractor which can do row crop work and can also plough (while a tractor which is primarily constructed to plough cannot do row crop work at all). This, in all parts where the cost of labour is high, is a great advantage. This tractor is designed to intercultivate and ridge up, being of special construction with a very small turning radius, and all the implements working within or under the wheel spread. It will also plough two furrows and looks to be an exceptionally efficient design.

STATEMENT No. 3

Fuel Consumption

Name of tractor	Working hours	K. Oil		Crude Oil		Petrol		Engine and gear Oil		Grease		Waste	
		Total galls.	Per hour galls.	Total galls.	Per hour galls.	Total galls.	Per hour galls.	Total galls.	Per hour galls.	Total lb.	Per hour lb.	Total lb.	Per hour lb.
Lanz Bulldog semi-Diesel 15/30 H. P.	437.04	20.54	0.05	637.53	1.50	..	..	76.78	0.18	76.00	0.17	38.00	0.09
McCormick Deering 15/30 H. P. K. Oil.	356.92	962.20	2.69	..	..	22.00	0.06	88.68	0.24	70.05	0.19	34.00	0.09
Vickers 23/40 H. P. K. Oil.	163.97	554.55	3.38	..	..	11.00	0.06	44.57	0.27	30.00	0.18	17.37	0.11

STATEMENT No. 4

Analysis of total cost

Name of tractor	Kerosine oil		Crude oil		Petrol		Lubricants and waste		Wages of mistris and water carriers		Wages of repairing staff		Spare parts		Total		Expenses per hour	
	Rs.	A. P.	Rs.	A. P.	Rs.	A. P.	Rs.	A. P.	Rs.	A. P.	Rs.	A. P.	Rs.	A. P.	Rs.	A. P.	Rs.	A. P.
Lanz Bulldog semi-Diesel 15/30 H. P.	15	6 10	287	10 3	..	..	207	1 4	62	8 9	135	6 0	999	12 3	1,707	13 5	3	14 6
McCormick Deering 15/30 H. P. K. Oil	721	10 3	..	..	35	12 0	197	7 11	75	13 2	175	2 3	952	4 3	2,158	1 9	6	0 9
Vickers 23/40 H. P. K. Oil	415	14 5	..	..	17	14 0	113	11 8	29	13 10	116	11 3	405	14 9	1,100	0 0	6	11 3

STATEMENT No. 5

Cost per acre

Name of tractor	Ploughing		Disc-harrowing		Grubbing		Rolling		Drilling	
	Rs.	A. P.	Rs.	A. P.	Rs.	A. P.	Rs.	A. P.	Rs.	A. P.
Lanz Bulldog semi-Disc 15'30 H. P.	.	4 10 4	2 5 0		2 0 0		1 3 10		1 8 11	
McCormick Deering 15'30 H. P. K. Oil	.	5 15 1	3 3 8		2 11 6		1 15 6		2 12 6	
Vickers 23'40 H. P. K. Oil	.	4 13 1	2 14 0		2 13 0		1 15 0		2 1 7	

Statement showing the output, consumption and cost of belt pulley work by tractors for the year 1933-34

Name of tractor	Working hours	Fuel and lubricants, etc.	Wages of mistris and water carriers		Wages of repairing staff		Spare parts		Total		Expenses per hour	
			Rs.	A. P.	Rs.	A. P.	Rs.	A. P.	Rs.	A. P.	Rs.	A. P.
McCormick Deering 15'30 H. P. K. Oil	89.91	179 5 4	17	4 7	49 10 6		239 2 6		485 6 11		5 6 3	
Vickers 23'40 H. P. K. Oil	25.25	70 1 10	4	3 11	17 14 9		62 5 9		154 10 3		6 1 11	

2. SPREAD OF IMPLEMENTS

This line of investigation has been considerably handicapped by the fact that the crude-oil tractors now being worked, do not exactly rank up with any actual types of kerosine oil tractors they succeed, while the latest crude-oil track types are of far greater H. P. than is really required in this tract. Investigations on the lines of a hinged plough are being taken in hand and the possibilities of increasing or decreasing at will the gangs on a disc-harrow. The chief trouble, however, lies in the fact that at present an efficiently harnessed tractor of 40 H. P. is pulling a plough which is a solo implement and to all intents and purposes part of the tractor, for no other tractor, unless of similar H. P. can utilise it efficiently ; while if arrangements are made to stack a fleet of disc-harrows behind this tractor to produce efficiency, the headland required for this procession is enormous and small fields have to be left untouched. Drills and grubbers are the same, to be efficient they must be of maximum spread and this cannot but tend to increase the capital cost of implements based on the tractor H. P. All this points to the essential need of variable spreads, so that implements may be fewer and common to all sizes of tractor, and a large amount of capital now invested in idle implements may be set free for other work.

3. THRESHER

The bullock gear threshing outfit designed for work last year, details of which have been already published, worked for 112 hours over a period of 31 days and threshed wheat off 43.38 acres. The output was 490 maunds of grain.

During the year a hand winnower was designed and completed to work with the bullock gear outfit. It worked with the thresher throughout the season and proved very satisfactory in dealing with the output threshed daily.

The complete outfit now consists of : —

	Rs.
Thresher	450
Bullock gear	335
Winnower	230

and is available from Messrs. Arthur Butler & Co., Muzaffarpur (complete set for Rs. 1,000).

4. DUNLOP PNEUMATIC EQUIPMENT FOR BULLOCK CARTS

Four sets of wheels, tyres, axles and roller bearings were received from the Dunlop Company of India for trial on bullock carts.

They were fitted under four cart bodies (one iron and three wooden) specially designed and constructed here for heavy cane carting. They were fully tested throughout the season under loads of cane varying from 40 to 60 maunds carted either to the railway station (6 miles) or direct to the mill (14 miles).

They stood up to every test excellently and showed no sign of any wear and tear and reduced carting costs to a marked extent. The results of the trials have been written up and sent for publication. Further trials are in progress to test the farm life of the tyres.

XI. CATTLE BREEDING

The Pedigree Sahiwal herd stood at 217 head during the year under report. One cross bred cow alone remains in the milch herd (Appendix, Table I).

It will be noticed that though the milch herd numbers were reduced by twenty-one, the total milk yield remained at 3,00,690 lb. as against 2,99,990 lb. last year. The total quantity of milk sold during the year was 1,23 952 lb. as against 1,37,051 lb. in 1932-33.

Special calf rearing experiments in relation to early maturity.—These were continued during the year and account for the large quantity of milk fed to calves which was 1,20,302 lb. against 94,269 lb.

Pensioners and cows giving no milk, and only kept for breeding, were removed from the milch herd total in order to obtain a clear idea of the actual "in milk" percentage of the herd, while draft cows put aside for sale were similarly omitted. This has resulted in the "in milk" percentage of the herd rising from 55.1 to 66.2 (Appendix, Table II) which now gives an accurate idea of the actual figure. In past years this was frequently very low due to breeding cows which did not milk and cows pensioned off being included with the actual milking stock.

During the year under report the determination of the herd butter fat was done daily.

Berseem hay was fed to the herd from April to June and oat hay during the same period; both of these have proved excellent dry fodder and have materially helped in maintaining a suitable ration for the herd. Feeding experiments are now in progress in collaboration with the Physiological Chemist to find out the exact food value of these fodders.

Milk yield.—The average herd yield per cow per day rose from 17.9 lb. to 18.7 lb. in the year under report. Four times milking was continued throughout the year and the highest herd yield per

PLATE I

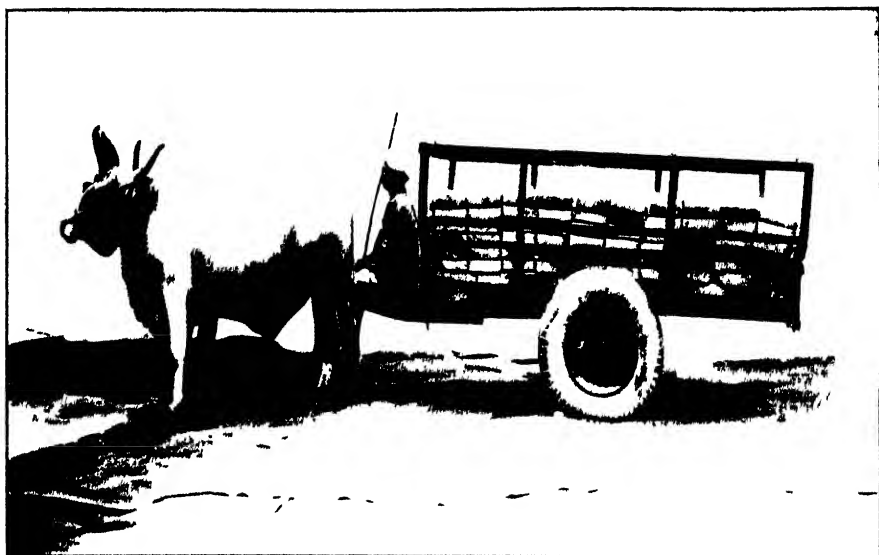


Fig. 1 Dunlop non cut loaded with 600 bricks (60 mds.)

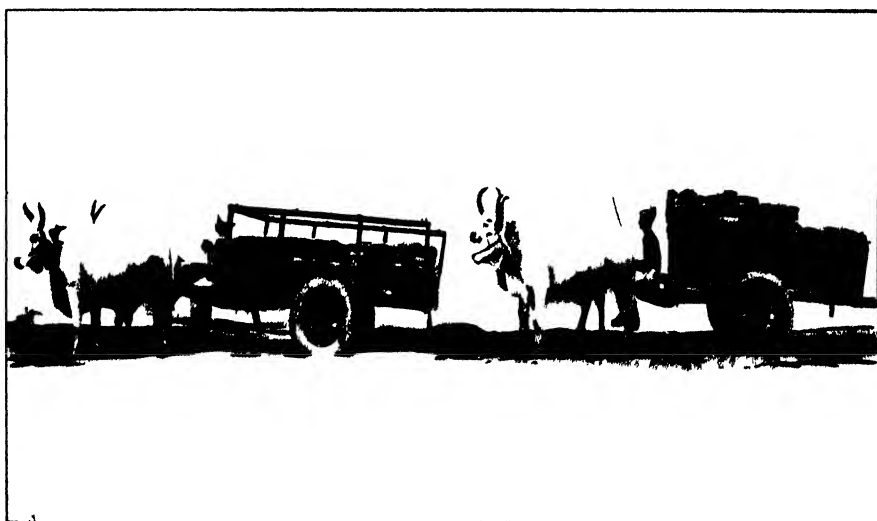


Fig. 2 Dunlop non cut loaded with 600 bricks (60 mds.)

Fig. 3 Dunlop wooden cut loaded with 650 bricks (65 mds.)

cow per day was 22·0 lb. for the month of April (Appendix, Table II). The second report on special feeding and handling was issued, and the experiment is now being carried on for the third year. A notable increase in the heifer yield was seen, and the figures for the last ten years are given for comparison (Appendix, Table III). All heifers were pre-milked and underwent the usual training which is now standard in the herd (See First Report on Feeding and Handling Experiments on the Pusa Pedigree Sahiwal herd).

No udder trouble of any description was experienced during the year. All cows are milked out prior to calving and no trouble is experienced even with the heaviest yielders.

In Appendix—Table IV, the lactations of some of the best cows and heifers are given.

In Appendix—Table V, the list of cattle disposed of is given. Good prices were realised and the demand for the stock continued to be good. As usual, all male stock not upto standard was castrated before sale.

Calf rearing.—This year shows a large increase in the mortality among pail-fed calves, which has risen from 2·4 per cent. to 13·2 per cent. (Appendix, Table VI). This was entirely due to an epidemic form of enteritis with lung complications which occurred directly after the earthquake. This was in no way connected with the method of rearing adopted here, and the mortality figure is now nil.

The early maturity experiments were continued throughout the year and further data collected.

Bull Lakhan, who, as reported last year, started service at eighteen months, has continued to serve successfully and now at the age of three years is of full average size and weight. His calves are also fully upto standard and show no signs of any deterioration. On the female side, work is being continued and the heifers going to bull are of full average weight despite their early age. Much interesting and important data are being collected, and a first report will issue in due course.

The standard calf weights for special and ordinary feeding from birth to 52 weeks were worked out and a paper has been sent for publication.

Earthquake.—A severe earthquake was experienced on the 15th January, 1934. Buildings were badly shaken and much confusion caused, but not a single head of stock received any injury and the entire staff are to be praised for the plucky way in which during the earthquake, without any thought of their own risk, they extricated all cattle from the buildings, which in some cases were near collapsing.

Lines of work

1. To establish milk ;
2. To improve milk yield ;
3. To fix a type incorporating as far as possible the physical characters of the best milkers ;
4. To definitely grade out all beef type transmitters from the herd ;
5. To fix certain definite characters in the breed which are regarded as essential by all judges and breeders ;
6. To adopt a system of advance registry ;
7. To trace and fix certain characters transmissible and hereditary and link them definitely with certain lines ;
8. To grade the whole milch herd into classes ;
9. To establish definite data for the correction of milk records in order to bring them into line with other herd records ;
10. To discover and record the best method of feeding, milking and handling the breed linked with the question of reabsorption of milk ;
11. To work out the possibility of higher feeding with earlier maturity, increasing the earning period of each cow ;
12. To settle the most profitable calving intervals for each lactation ;
13. To study carefully the effect of all line-breeding already done and its guide to subsequent work ;
14. The effect of in-breeding on the yield, constitution and general condition of the Sahiwal, particularly with relation to fertility ;
15. To investigate any Mendelian ratio which may be evident in transmission and to endeavour to trace any definite line of inheritance of characters under this law.

XII. PUBLICATIONS

- | | | | | |
|----------------|---|---|---|--|
| 1. Wynne Sayer | . | . | . | Berseem as green fodder, hay and silage,
<i>Agri. and Live-stock in India</i> , 1934, 4, 21-28. |
| 2. ———— | . | . | . | Feeding and Handling Experiments on the
Pusa Pedigree Sahiwal Herd, 1932-33
(First Report), <i>Agri. and Live-stock in
India</i> , 1934, 4, 105-12 . |
| 3. ———— | . | . | . | The Study of Threshing Problems at Pusa,
<i>Agri. and Live-stock in India</i> , 1934, 4, 197-207. |
| 4. ———— | . | . | . | Mill Trial of Co. 299, <i>Agri. and Live-stock
in India</i> , 1934, 4, 407-411. |

(Articles in the Press.)

5. Wynne Sayer	Early Maturity Experiments.
6. Wynne Sayer and Vaidyanathan, M.	Ideal size and shape of sugarcane experimental plots based upon Tonnage Experiments with Co. 205 and Co. 213 conducted at Pusa.
7. Wynne Sayer	Feeding and Handling Experiments on the Pusa Pedigree Sahiwal Herd (Second Report, 1933-34).
8. —————	Tests on Dunlop Pneumatic Equipment for Farm Carts, Season 1933-34.
9. —————	Tables of Pail-fed Calf Weights during Ordinary and Special Feeding.

XIII. PROGRAMME OF WORK FOR 1934-35

1. Cultivation investigation with special reference to production of tilth and condition of soil associated with speed of implements.

2. Green-manuring investigations with special reference to water requirements in various soils and conditions required by different crops.

3. General treatment of a 600-acre farm with special reference to reduction of costs in cultivation and the rotations suitable to the introduction of machinery.

4. Line-breeding investigations with a pedigree herd of Sahiwal cattle with special reference to the transmission of milch characters.

5. Experiments on feeding and digestion trials in collaboration with the Physiological Chemist to determine the digestive capacity of Indian cattle.

6. Special feeding of young calves with a view to early maturity to lengthen the profit period of the average Sahiwal cows and bulls.

7. Investigation of the threshing problem in India and the design of a small threshing plant to suit all-India requirements.

8. Experiments with various types of motor tractors and general tractor implements for collection of data and determination of most suitable types of tractors and implements for Indian conditions.

Collaboration with manufacturers with regard to the manufacture and test of new types of implements built to correlate with present tractor design.

9. Investigations on silage problems.

10. Experimental work—

(a) The design, layout and general technique connected with modern field experiments.

(b) Trials of new varieties of crops.

(c) Manurial experiments.

- (d) Trials of sugarcane varieties suitable for growth without irrigation for various classes of soils and withripening dates corresponding to the alteration in factory conditions.
 - (e) Rotational experiments.
 - (f) Crop experiments in collaboration with Sectional Officers.
11. Training of post-graduate students.
 12. Touring and advisory.
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APPENDIX

TABLE I

Annual statement of Live-stock as it stood on the 30th June, 1934

Serial No.	Breed and description of cattle.	No. of animals from last year	INCREASE			DECREASE				Total	
			By birth	By transfer	Transfer from N. Area	By death	By transfer	By sale	Transfer- red to Estate and Farm		Sent to Pintra- pole
1	Bull	10	..	3	..	3	13	..	..	..	10
2	Cow	80	..	25	..	2	2	27	..	4	59
3	Young male stock	60	33	..	..	8	3	18	12	..	52
4	Young female stock	67	36	..	..	3	12	5	..	..	83
5	Progeny of Sahiwal cows and Ayrshire bulls.										
	Cow	2	..	..	..	..	..	..	..	1	1
6	Miscellaneous crosses										
	Cow	1	..	..	..	..	..	..	..	..	1
7	Young male stock	1	..	..	..	..	..	..	..	..	1
8	Young female stock	1	..	..	..	..	..	..	..	..	1
9	Cart bullocks	5	..	..	8	..	4	..	..	..	9
	Total	227	69	28	8	16	32	50	12	5	217
10	Sheep—										
	Male stock	23	13	..	..	9	..	..	..	..	27
	Female stock	55	16	2	..	21	2	..	..	..	50
	Total	78	29	2	..	30	2	..	..	..	77

TABLE II

Statement of milk yield for 1933-34

Month	Yield (excluding stripp- ing)	Average per day	Average yield per cow per day	NUMBER OF COWS IN MILK AND DRY			
				Total No.	In milk	Dry	Per- centage in milk
	lb.	lb.	lb.				
July 1933 . .	29,518	952	17·3	80	55	25	68·7
August 1933 . .	28,060	905	16·8	80	54	26	67·5
September 1933 . .	22,421	747	16·2	78	46	32	59·0
October 1933 . .	20,604	665	16·6	79	40	39	50·6
November 1933 . .	20,057	669	16·7	59	40	19	67·8
December 1933 . .	21,369	689	18·1	60	38	22	63·3
January 1934 . .	21,646	698	18·4	60	38	22	63·3
February 1934 . .	20,442	730	18·7	61	39	22	63·9
March 1934 . .	24,886	803	21·1	57	38	19	66·6
April 1934 . .	26,474	882	22·0	47	40	7	85·1
May 1934 . .	23,821	768	21·9	50	35	15	70·0
June 1934 . .	21,460	715	20·4	51	35	16	68·6
AVERAGE . .	23,396	769	18·7	63	41	22	66·2
Average for 1932-33	23,170	761	17·9	77	42	35	55·1

TABLE III
Sahiwal Heifers—Pusa Herd

Statement showing average yield per day, 1925—34

[illegible]

TABLE IV

Milk yield of some of the best cows and heifers during 1933-34.

Name and No. of cow.		Date of birth	No. of calving	Milk yield lb.	(Days)
<i>Cows</i>					
1. Ramati	566	19-3-27	3	8,327	(304)
2. Ajbi	567	10-5-27	3	8,015	(304)
3. Adami	503	25-5-24	5	7,850	(303)
4. Nasoorti	427	8-3-21	8	7,546	(304)
5. Lalagi	596	6-1-29	2	7,425	(304)
6. Makhi	557	14-10-26	4	7,082	(306)
7. Lakhni	587	8-5-28	3	7,009	(304)
<i>Heifers</i>					
1. Brisoorti	609	28-2-30	1	6,036	(303)
2. Birkli	615	3-6-30	1	4,479	(306)
3. Lachrama	612	11-4-30	1	4,042	(289)

TABLE V

Statement showing the disposal of cattle during 1933-34

		Price	Average		
		Rs.	Rs.	A.	P.
16	Sahiwal young bulls	880	55	0	0
23	„ cows	3,020	131	5	0
4	„ heifers	355	88	12	0
Total	43				
4	Sahiwal cows sold on nominal price.				
10	„ steerlings—transferred to Farm.				
2	„ „ —transferred to Estate Office.				
4	„ cows				
1 ½	Ayr. Sahiwal cow } —sent to Samastipore Pinjrapole.				
3	Young bull-calves sold with cows.				
Total	67				

TABLE VI

Calf mortality figures (Pail-fed period)

Year	Birth	Death	Percentage of mortality	
1932-33	84	2	2.4	
1933-34	68	9	13.2*	*Due to enteritis.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST

(F. J. F. SHAW, D.Sc., A.R.C.S., F.L.S.)

(1) BOTANICAL SECTION, PUSA.

I. ADMINISTRATION.

Dr. Shaw held charge of the Section throughout the year under report. Dr. B. P. Pal, M. Sc., Ph.D. (Cantab.), F.L.S., was appointed Second Economic Botanist with effect from the 30th October, 1933. Mr. Kashi Ram held the post of Officiating Assistant Economic Botanist upto the 10th April after which he was transferred to Karnal as Officiating Superintendent of the Botanical Sub-Station. Mr. R. D. Bose was confirmed in the class II post of Special Research Assistant with effect from the 1st March 1934 and was appointed as Officiating Assistant Economic Botanist from the afternoon of the 10th April *vice* Mr. Kashi Ram transferred to Karnal. Mr. R. B. Deshpande was confirmed as an assistant on the 1st March and appointed to officiate as Special Research Assistant from the 27th April, 1934. Dr. A. A. Quarashi, Ph. D., officiated as an assistant from the 2nd January to the 28th February, 1934.

A sum of Rs. 1,945-1-9 was realized from the sale of improved seeds, etc., and credited to Government during the financial year ending the 31st March, 1934. Owing to the great increase in experimental work, the area allotted to bulk crops is annually decreasing in the Botanical Section and hence the work of multiplying and distributing seed of improved types of crops has to be largely carried out on the Pusa Farm in collaboration with the Imperial Agriculturist and at the Botanical Sub-Station at Karnal.

TRAINING.

Mr. S. Majid, B.Sc., completed his post-graduate training during the year and was of material help in the investigations with which he was concerned.

Messrs. Sarvayya Chetti, Pushkar Nath, Abdul Aziz, S. V. A. Hydari and M. P. Bhatnagar continued to receive their training. Mr. P. Krishna Rao, Parlakimedi Scholar from Madras, Mr. S. B. Vaidya, King Edward Scholarship holder from the Central Provinces, and Messrs. A. Pal and S. Z. Hasanain, private students from Bengal and the United Provinces respectively, were admitted this year for the full post-graduate course in Economic Botany.

All these students were sent to Karnal in the second week of March, for about a week, in order to study the growth and behaviour of crops under irrigated conditions.

Mr. T. C. N. Singh, Officiating Assistant Economic Botanist, Bihar and Orissa, Sabour, and Mr. R. B. Ekbote, Farm Assistant, Karnal, were given a special course of lectures on the lay-out and statistical interpretation of field trials in July, 1933.

Three students from the Agricultural Section and two from the Chemical Section were permitted to attend the course of lectures delivered in this Section on biometry and statistical methods. One of the Agricultural students continued to attend the lectures on genetics also.

Messrs. San Maung (Burma), S. N. Choudhury and B. R. Mandal (Bihar and Orissa), H. S. Gupta and Inam Ahmed (United Provinces), Ram Dittamal (Punjab), Lodhi A. K. Khan (Sind), B. Subba Rao (Central Provinces), and Gopal Ratnam (Madras), were admitted in January 1934 for a special course of training in flue-curing of tobacco. Owing to a severe hailstorm which damaged the tobacco crop and because of the earthquake of the 15th January damaging the flue-curing barn, the course was curtailed.

SEASON AND RAINFALL.

The rains commenced rather early and the total annual rain fall exceeded the average for the last 25 years by 6.28 inches. The distribution was fair though July received an excess of 7.87 inches. The year was a very bad one as far as rusts are concerned for the attack of both wheat and linseed rusts was very severe, particularly of the latter. The unusually heavy incidence may have been due to rather heavy rain in January.

Statement of rainfall in the Botanical Section in 1933-34.

Month				Average for last 25 years. 1906—1930	From 1st June 1933 to 31st May 1934	Difference
June	1933	.	.	7.53	8.57	+1.04
July	"	.	.	11.08	18.95	+7.87
August	"	.	.	14.09	10.98	-3.11
September	"	.	.	8.05	9.35	+1.30
October	"	.	.	1.81	2.25	+0.44
November	"	.	.	0.43	0.00	-0.43
December	"	.	.	0.18	0.00	-0.18
January	1934	.	.	0.34	1.94	+1.60
February	"	.	.	0.68	0.45	-0.23
March	"	.	.	0.41	0.07	-0.34
April	"	.	.	0.56	0.00	-0.56
May	"	.	.	1.44	0.32	-1.12
Total				46.60	52.88	+6.28

The most noteworthy features of the season were the hailstorm of the 13th January, 1934, and the great earthquake of the 15th January. The former completely ruined the tobacco crop and also caused wheat, barley, *rahar*, etc., to lodge. The earthquake was responsible for the appearance of a moderate sized fissure in Barah 4 plot through which a certain amount of water followed by sand was ejected; no further damage to land was done in the Botanical Section except near the bhusa shed which was the only building badly damaged in the Section.

Statement showing the seed distribution in 1933-34 of improved crops evolved in the Botanical Section, Pusa.

Crop	Variety	QUANTITY DISTRIBUTED IN LB.		Total
		By the Botanical Section, Pusa	By the Pusa Farm	
Barley	Type 1	20.5	..	20.5
	" 2	14.5	..	14.5
	" 7	1.0	..	1.0
	" 12	11.0	..	11.0
	" 19	1.0	..	1.0
	" 20	11.0	..	11.0
	" 21	1422.0	1647.0	3069.0
	" 22	15.0	..	15.0
	" 23	15.0	..	15.0
	R-1	10.0	..	10.0
Chillies ,	Type 34	1.6	..	1.6
	" 38	.1	..	.1
	" 41	1.1	..	1.1
	" 46	.6	..	.6
	" 51	1.2	..	1.2
Ganja	Type 1	164.6	..	164.6
Gram	Type 2	1.5	..	1.5
	" 6	42.6	..	42.6

Seed distribution in 1933-34—(contd.)

Crop	Variety	QUANTITY DISTRIBUTED IN LB.		Total
		By the Botanical Section, Pusa	By the Pusa Farm	
Gram—contd.	Type 17 . .	285·6	2633·1	2918·7
	„ 25 . .	229·4	966·9	1196·3
	„ 28 . .	255·5	..	255·5
	„ 58 . .	278·6	246·9	525·5
	„ 51 . .	6·5	..	6·5
	„ 48 . .	6·5	..	6·5
	„ 49 . .	6·5	..	6·5
	„ 53 . .	49·0	..	49·0
	„ 54 . .	16·6	..	16·6
	„ 67 . .	22·8	..	22·8
	„ III-86 . .	55·9	658·3	714·2
Lentil	„ 47 . .	·3	..	·3
	„ III-54 . .	·3	..	·3
	„ III-55 . .	·3	..	·3
	„ 220 . .	·3	..	·3
	„ 12 . .	130·0	..	130·0
Linseed	„ 121 . .	78·0	..	78·0
	„ 124 . .	56·6	..	56·6
	Hybrid 10 . .	321·0	..	321·0
	„ 21 . .	47·0	..	47·0
	„ 38 . .	7·5	..	7·5
	„ 55 . .	72·0	..	72·0
	„ 68 . .	65·8	..	65·8
	„ 12 . .	130·0	..	130·0
Oats	B. S. 1 . .	278·0	39498·3	39776·3
	„ 2 . .	83·0	1152·0	1235·0
	Hybrid A . .	4·0	..	4·0
	„ B . .	4·0	..	4·0

Seed distribution in 1933-34—(contd.)

Crop	Variety	QUANTITY DISTRIBUTED IN LB.		Total
		By the Botanical Section, Pusa	By the Pusa Farm	
Oats— <i>contd.</i>	Hybrid C	343·0	987·4	1330·4
	„ D	4·0	165·6	169·6
	„ E	4·0	..	4·0
	„ F	4·0	..	4·0
	„ G	24·0	..	24·0
	„ H	4·0	..	4·0
	„ I	4·0	..	4·0
	„ J	87·0	..	87·0
	„ K	4·0	..	4·0
Paddy	Type 24	258·1	..	258·1
	„ 31	518·1	..	518·1
	„ 52	309·1	..	309·1
	„ 18	13·1	..	13·1
	„ 60	10·0	..	10·0
	„ 97	20·0	..	20·0
Patua	„ 3	·1	..	·1
	„ 6	41·1	..	41·1
	<i>Now Patua</i>	164·0	..	164·0
Pea	Type 14-1	..	205·7	205·7
Rahar	„ 6	1·0	..	1·0
	„ 15	30·0	164·6	194·6
	„ 16	136·1	..	136·1
	„ 24	11·5	205·7	217·2
	„ 41	1·0	..	1·0
	„ 50	1·0	..	1·0

Seed distribution in 1933-34—(contd.)

Crop	Variety	QUANTITY DISTRIBUTED IN LB.		Total
		By the Botanical Section, Pusa	By the Pusa Farm	
<i>Rahar—contd.</i>	Type 51	235·4	374·4	609·8
	„ 64	22·0	..	22·0
	„ 69	1·0	..	1·0
	„ 80	10·0	82·3	92·3
	„ 82	22·0	..	22·0
Rai Seed	....	4·0	..	4·0
Safflower	Type 30	102·1	..	102·1
Sarson Seed	....	4·0	..	4·0
Sesamum	Type 3	1·5	..	1·5
	„ 7	2·5	..	2·5
	„ 29	11·9	..	11·9
	„ 30	·3	..	·3
Tobacco	„ 28	15·6	..	15·6
	„ 58	·013	..	·013
	„ 63	·013	..	·013
	N. Rustica Type 18	2·6	..	2·6
	Hybrid 142	·025	..	·025
	„ 177	3·5	..	3·5
	Cash	·013	..	·013
	Adcock	1·1	..	1·1
Wheat	Pusa 4	35·3	658·3	693·6
	„ 12	506·0	6697·0	7203·0
	„ 52	89·0	1664·2	1753·2
	„ 80—5	195·0	..	195·0

Seed distribution in 1933-34—(concl'd.)

Crop	Variety	QUANTITY DISTRIBUTED IN LB.		Total
		By the Botanical Section, Pusa	By the Pusa Farm	
Wheat— <i>cont'd.</i>	Pusa 101 . . .	37 5	1241·6	1279·1
	" 111 . . .	47 0	1188·0	1235·0
	" 112 . . .	43 0	..	43·0
	" 114 . . .	32 0	..	32·0
	" 120 . . .	41 0	..	41·0
	" 165 . . .	41·5	..	41·5
	" 113 . . .	2·0	..	2·0
	" 12-2 (New) .	61 0	..	61·0

II. INVESTIGATIONS.

WHEAT (*Triticum vulgare* Host).

Although in the year under report rust was unusually severe, the yields were, as a rule, above the average. The highest yielders at Pusa were Pusa 101 which grown on an area of 0·32 acre gave an outturn of 2584·4 lb. per acre and Pusa 52 which grown on an area of 0·65 acre gave an outturn of 2449·5 lb. per acre. The bushel weights, however, were lower than those of last year, though with the exception of Pusa 12 higher than the average for the past few years. This may be seen from the following table :—

TABLE I.

Showing bushel weights of some Pusa wheats.

Variety	WEIGHT PER BUSHEL IN LB.		
	Average for the past six years ending 1931-32	1932-33	1933-34
Pusa 4	63·68	66 3	64·36
Pusa 12	61·93	64·3	59·76
Pusa 52	64 00	66·4	65·67
Pusa 101. . . . .	..	67·1	65·77
Pusa 111. . . . .	..	66·1	64·58

Pusa 114 has proved to be a great success in Sind and during the present season has been sold at a premium of 12 per cent. It has also given very high yields in the Punjab. Pusa 101 yielded over 33 maunds (2715·4 lb.) per acre at the Government Agricultural Farm, Meerut, where it was grown on an area of one-tenth of an acre and 27·7 maunds (2279·3 lb.) at Sepaya, and a report from Bhopal stated that this wheat "appears to have possibilities for local spreading and being largely rust resistant should also be better than some of the C. P. types". Pusa 52 yielded 32 maunds 26 seers 4 chataks (2687·1 lb.) per acre at Meerut and 26 maunds at Sepaya. Pusa 80-5 gave over 40 maunds (3291·4 lb.) per acre at Meerut where it was grown over an area of one tenth acre.

The most promising of the hybrids obtained from crosses between the Australian variety Federation and Pusa 4 and Pusa 52 were tested against the two Pusa parent types and were under yield trial for the second year. The yield trial was laid out in duplicate, one Latin square being put in a manured, and the other in a non-manured field. In the latter Pusa 52, i.e., one of the parent varieties, was significantly better than the hybrids; in the former, however, Pusa 52 though superior to the other hybrids, was surpassed in yield by Hybrid 61-1-1-3, the difference being statistically significant. Although most of the hybrids are not superior to the parent varieties in yield, some of them nevertheless possess certain desirable features such as resistance to disease which may render them of agronomic value. Two of them, now designated as Pusa 120 and Pusa 165 which gave very good results at Karnal were tried out on various farms in the Punjab and in the United Provinces. The results of these trials are being awaited with interest. Pusa 12-2, a strain bred from a rogue plant in Pusa 12, was tried on a large scale this year and was found to be similar to Pusa 12 in yielding capacity.

Pusa 52 and a local wheat obtained from the Deputy Director of Agriculture, Muzaffarpur, were tested this year for the second time, the form of lay-out adopted being the parallel strip method. The average yield per acre of Pusa 52 was 1219·65 lb. while that of the local variety was only 884·78 lb., the difference being statistically significant. Though beaten ultimately in growth, tillering and yield, the local variety looked more vigorous in the early stages because of its erect habit and greater height, Pusa 52 having a semi-erect habit.

A vernalization experiment with Pusa 101 and Punjab 8A wheats proved to be insignificant, the treated and non-treated plots giving similar results.

BARLEY (*Hordeum vulgare* L.).

Barley continued to receive a good deal of attention in the Botanical Section. A number of qualitative and quantitative characters were studied in great detail in the F_2 generations of two crosses, viz., type 21 \times type 1 and type 21 \times Nepal hooded barley. The data are being analysed and the mode of inheritance of different characters will be determined from this. In the cross type 21 \times type 1, the mother parent, type 21, is a 6-rowed barley and the male parent, type 1, is a 2 rowed barley which differs from all other Pusa barleys in possessing broad outer glumes in the ear-head. It has been found that single factors are responsible for the inheritance of the following characters :—

- (1) Fertility of the lateral florets—the ratios of 2 rowed : intermediate : 6-rowed being as 1 : 2 : 1.
- (2) Awns on the inner glumes of the lateral florets—1 nil : 2 intermediate : 1 full.
- (3) Nature of outer glumes—3 narrow : 1 broad.

The inheritance of items (1) and (2) seems to depend upon the interaction of the same genetic factors and there appears to be a complete linkage between :—

2-rowed fertility and no development of awns on the lateral florets,

Intermediate fertility and the development of pointed or tipped awns on the lateral florets, and

6-rowed fertility and development of fully developed awns on the lateral florets.

There is no linkage between fertility and nature of outer glumes and (1) maturity as measured by the number of days taken by individual plants to head out, (2) length of ear-heads and (3) internode length as represented by the length of 10 internodes in cm.

In the case of the other cross, viz., type 21 \times Nepal hooded barley, the hooded character seems to be dominant to the awned, the proportion being three hooded to 1 awned, but the presence of many grades of hooded character indicates that more than one factor is responsible for this inheritance.

In a cross between the 2-rowed Chevalier and the 6-rowed Pusa type 21 barley, 21 plants out of a total population of 374 in the F_2 generation were observed to possess branched ear-heads in 1931-32. Neither the two parents nor the F_1 hybrids showed this feature but the F_2 and the following two generations showed that duplicate factors were responsible for the inheritance of this character and that the branched ear genotype was the double recessive. It was

also found that the factors for branched ears segregated independently of the factors for the fertility of the lateral florets. A paper on this subject has been submitted for publication.

In a cross between a lodging (type 1) and a non-lodging (type 21) barleys, the examination of F_2 plants by cutting transverse sections of the culms disclosed that the development of mechanical tissues is also controlled by Mendelian factors. In the non-lodging phenotypes, the sclerenchyma is thick and well developed and there are regular sub-epidermal girders which help to strengthen the culm; in the lodging type, on the other hand, it has been found that the sclerenchymatous tissue is poorly developed and there are hardly any sub-epidermal girders present. The F_2 study will confirm the nature of segregation for this character.

Helminthosporium causes a serious disease of barley and investigations are in progress in collaboration with Dr. Mitra of the Mycological Section, Pusa, regarding the comparative susceptibility to this fungus of the twenty-four types of barley evolved at Pusa. Details of this work will be found in the report of the Imperial Mycologist. The different types vary in their resisting power but none of them have shown complete immunity to the disease. Partial control appears to be obtained by seed treatment and hence initial infection is due mostly to natural seed infection.

The study of the inheritance of resistance to *Helminthosporium sativum* P. K. and B. in two crosses of Pusa barleys has been conducted in the Botanical Section, and it is found that multiple genes are responsible for the inheritance of this character and that resistance to this disease is dominant to susceptibility. A paper on this subject has recently been sent in for publication.

A study of inheritance of striped leaves in barley is in progress and a preliminary study on the effect of vernalization in barley has been taken up.

OATS (*Avena sterilis* L.).

Favourable reports regarding the yielding power of B. S. 1 and 2 and hybrids C and J oats have been received from many parts of India where they have been tried during the year under report. The response of different types to variations in soil and climate is very well elucidated by yield trials conducted for the last three years with eleven hybrids and B. S. 1 and B. S. 2 in two different places, viz., Pusa and Karnal under different sets of conditions. At Pusa the crop was grown without irrigation while at Karnal the usual irrigations were given. Whereas in the first year of the experiment, i.e., 1931-32, the yields of these thirteen types of oats varied considerably with the locality, the final conclusions based on the results of three seasons' investigations at each

place were more or less in agreement with each other. This is shown in the following table :

Average yields in lb. of Pusa oats taken from plots 1,000 square feet in area.

Year	Localities	VARIETIES												
		A	B	C	D	E	F	G	H	I	J	K	L	M
1931-32	{ Pusa	25.5	24.7	24.4	26.3	30.9	34.8	30.2	22.2	23.1	31.8	27.2	44.3	32.2
	{ Karnal	41.3	29.3	42.1	40.6	35.7	34.4	48.7	36.5	32.8	44.3	49.4	31.8	35.6
1932-33	{ Pusa	34.0	29.4	59.1	45.1	46.3	50.3	54.4	34.0	53.7	56.7	37.2	52.3	57.2
	{ Karnal	36.6	26.1	47.7	43.5	43.6	37.5	50.2	36.0	35.6	53.7	38.5	55.9	57.5
1933-34	{ Pusa	47.3	34.9	67.9	49.9	54.1	45.4	56.1	48.5	50.8	56.1	45.8	59.5	63.6
	{ Karnal	43.4	31.2	43.7	41.0	42.7	41.9	43.6	36.8	43.3	42.1	40.3	43.7	50.6
Average of three years	{ Pusa	35.6	29.66	50.46	40.48	43.76	43.5	46.9	34.9	42.6	48.2	36.7	35.28	51.06
	{ Karnal	40.43	28.86	44.5	41.7	40.66	37.93	45.83	36.43	37.23	46.7	39.4	43.8	47.9

If we had considered the yields of the different oats during 1931-32 only and based our recommendations on these results, we would have concluded that at Pusa, L. (B. S. 1) was the best yielder and hybrid C a very poor yielder, whereas at Karnal in the same year hybrid C was one of the best yielders and L. (B. S. 1) a very poor one indeed. The two results were diametrically opposed to each other. If, however, we take the accumulated results of three seasons' trials at each place, we find that save for seasonal differences the two types were ranked quite high for their yielding power and were in fact statistically not different from each other in this respect. This shows how erroneous it is to base conclusions on the results of trials conducted in one season or in one locality only and the necessity of conducting serial trials for a more exact evaluation of the different treatments.

The complete statistical analysis of this accumulated data show that the five highest yielders are oat types M, L, C, J and G which are ranked in this order but types L, C, J and G are not statistically different from each other and may all be classed as yielders of the same order. Amongst these five oats M is statistically superior to G only and not to any others. Hybrids A, B, H and K on the other hand, have not done well and must be ranked as indifferent yielders. A paper giving complete details of this trial and the method of working out serial experiments is being written up for publication.

Another example of the influence of soil and climate on the yielding power of some of these oats is furnished by the result.

obtained during the present year from a trial conducted by the Byreah Farm in the Bettiah Raj in North Bihar where B. S. 1 (P. 1) oats has significantly out-yielded hybrids C, F and J. The mean varietal differences together with the critical differences are shown below :—

Mean varietal differences in lb.

Varieties	C	P1	J	F
C		+6.08	+3.72	—0.38
P1	—6.08	..	—2.82	—6.46
J	—3.72	+2.82	..	—3.64
F	+0.38	+6.46	+3.64	..

Critical differences —

Differences greater than 3.05 and marked ===== are significant at the 1 per cent. level of significance.

Differences greater than 2.20 and marked ----- are significant at the 5 per cent. level of significance.

PADDY (Oryza sativa L.).

The work of isolating paddy types was completed in the year under review and 123 types have been finally retained. The most promising of these were put under preliminary yield trial and one autumn paddy (type 18) and three winter paddies (types 24, 31 and 52) have been picked out as being worthy of large scale tests.

Colour development in the paddy plant has been studied, particularly in the floral organs and a paper on this subject has been sent in for publication. The rices of Bihar and Orissa have been classified on the basis of this study and a paper on this classification has also been sent for publication. The main divisions of this classification are based on the chemical constitution of the rice kernel, presence or absence of clustering in spikelets, presence or absence of double-grained spikelets, length of the outer glume, and upon the presence or absence of elongated internodes with the production of aerial roots at the nodes. Next to this the colour of the inner glume has been deemed to be the most suitable criterion as the inner glume exhibits a wide range of easily distinguishable colours and affords a ready and convenient means of discrimination between varieties. After this the colour of the apiculus was considered to be the most suitable criterion and two distinct types of

apiculus colour designated as "restricted" and "spreading" apiculus respectively were distinguished. After the apiculus the colour of the outer glume is used and thereafter the colour of the kernel and internode and finally the grain size and shape are used in separating the ultimate classes.

Preliminary observations were made on the tillering capacity of certain varieties.

MAIZE (*Zea mays* L.).

The study of the inbred lines was continued and artificial pollination was performed to raise the selfed lines next year. It is also proposed to grow a collection of samples of maize obtained from different parts of India.

RAHAR (*Cajanus indicus* SPRENG).

An yield trial was again carried out with 10 promising types selected at Pusa and the local variety. Types 24 and 64 again proved to be significantly better yielders than the latter. The types in this yield trial experiment as well as the *rahar* grown in other plots were considerably damaged by the hailstorm of the 13th January. The flowers and pods of the *rahar* crop were damaged and the crop lodged badly owing to strong winds. In a preliminary trial with Pusa, types 15, 16, 41, 50, 80 and 82, No. 80, a wilt resistant type, occupied the first position at Sabour Farm, and types 24 and 51 did fairly well at Sepaya Farm. Type 51 is reported to have shown resistance to frost injury at Gwalior Farm.

The work on the inheritance of wilt-resistance in *rahar* or pigeon peas has been completed and is being written up for publication. It has been found that inheritance of wilt-resistance in this crop depends on the interaction of multiple factors and that these factors are inherited independently of the factors which are responsible for the inheritance of flower colour, seed colour, type of inflorescence and habit, as the phenotypic proportions among the survivors of an F_2 population in a wilt-infected field remained undisturbed.

During the year under review two F_2 populations which were grown in 1932-33 were carried to F_3 in infected fields in 1933-34. One of these populations was the complete progeny of a single F_1 plant and was grown under normal, uninfected conditions and contained 193 individuals and will be referred to as the 'B-Series'. The other F_2 population was also the progeny of a single F_1 plant and was grown under artificially infected conditions. In this population there were 98 survivors, the seed of which was carried to F_3 , and this will be referred to as the 'A-Series' in the following table which shows the distribution of the loss due to wilt disease among the F_3 families and the parent types.

Frequency distribution of the number of cultures with different degrees of wilt infection in Rahar cross Type 5 \times Type 80-F₃ grown in infected fields.

Year and Series	Seed	NO. OF CULTURES WITH DIFFERENT PERCENTAGES OF WILT INFECTION											Total
		0	10	20	30	40	50	60	70	80	90	100	
1933-34 Series A	F ₃	2	2	8	13	9	9	18	15	14	7	1	98
	Type 5	..	..	..	..	..	..	..	..	..	..	9	9
	Type 80	7	3	1	1	..	..	..	..	..	..	..	12
1933-34 Series B	F ₃	1	11	20	23	18	30	16	18	10	10	36	193
	Type 5	..	..	..	..	..	1	2	2	1	1	17	24
	Type 80	2	..	..	..	..	..	..	..	..	..	..	2

These frequencies suggest that in the A Series most of the susceptible plants had been destroyed by disease in the F₂ and that in F₃ these susceptible plants would have been non-resistant individuals which would be either heterozygous for factors for resistance or homozygous for their complete absence, while in the B Series in which elimination of the more susceptible genotypes in F₂ had not taken place, about 18 per cent. of the total number of cultures in F₃ have a death rate of over 90 per cent. In both the series, however, the distribution of resistance and susceptibility among the F₃ families shows that the inheritance of this disease is dependent upon multiple factors.

GRAM (*Cicer arietinum* L.).

The results of the cross between a kabuli type (Pusa No. 2) and a desi gram (Pusa No. 18) are being sent up for publication. The hybridisation work was continued at the Botanical Sub-Station, Karnal, in collaboration with the staff there and will appear in the report of that station.

Eight types, Nos. 48, 49, 51, 53, 54, 55, 58 and 67 were compared in yield with the old established types 17 and 25 in a randomised blocks lay-out with 6 replications. None of these surpassed type 17 this year, but type numbers 51, 54, 55 and 58 were significantly better than type 25 at the 1 per cent. level of significance. The latter was also significantly inferior to T. 17. The types that were best this year were Nos. 17, 51 and 58 and the difference between them was insignificant. Types 48 and 49 were the worst in yield and were badly attacked by blight. As these two types did not do well last year also, they have now been rejected from the yield trial.

Type 58 was significantly superior to type 17 in the past 2 years and this year, which is apparently not a favourable season for Type 58, the two are about equal. The reports received from various stations show that at these places type 58 has given higher yield than T. 17 or T. 25 but unfortunately no regular yield trials were conducted at these stations.

In a new yield trial types 17 and 41 were tested in parallel strips but the experiment was spoiled by an attack of cut-worm (*Agrotis Ypsilon*) which attacked T. 17 more severely than T. 41. The reason for this is being investigated.

The 84 types were maintained.

PEAS (*Pisum sativum* L. AND *P. arvense* L.).

The study of the types was continued and a paper describing these types is being written up for publication. The yield trial was repeated with 5 types, in a Latin square. The dwarf garden pea No. 14-1 again occupied the first position. The yield trial will be repeated next year when the final conclusions will be drawn.

LENTILS (*Ervum lens* L.).

Six hybrid lentils were tried against two high yielding selections in an 8 × 8 Latin square and under the conditions of the experiment it was found that the latter outyielded all the hybrids and that the bold seeded-lentils invariably gave lower yields than the small seeded forms. This experiment, however, will be repeated for some years more and the final conclusions will be based on the accumulated results of these trials.

Urid AND Mung (*Phaseolus Mungo* L. AND *P. radiatus* L.).

The pure lines of these two crops are being maintained. The urid crop was almost a complete failure during the year because the plot under this crop was badly flooded. A preliminary yield trial with some promising strains of *Mung* has been started. The F₂ generation of a cross between a green seeded *Mung*, type 18, and a yellow seeded one, type 36, was studied. A single factor seemed to be responsible for the inheritance of flower and pod colour and at least two factors were concerned in the production of green and yellow coloured seeds.

SUNN-HEMP (*Crotalaria juncea* L.).

The attempt to isolate a suitable strain of this crop continues and a preliminary study of the root system of different cultures evolved has been started. At the request of the Bengal Department of Agriculture and in collaboration with the Assistant Fibre

Expert, Bengal, a number of samples of Bengal sunn-hemp have been secured and the isolation of a suitable *rabi* strain for Bengal will be taken up this year. The ordinary *kharif* variety of this crop was sown during the *rabi* season this year but failed to develop normally.

INDIAN HEMP (*Cannabis sativa* L.).

Pusa types 1 and 2 of *ganja* were cured for the first time during the year under review and the product disposed of to the local Excise Department. Pusa type 1 appears to be a very promising strain for the production of the drug and some seed of this is being multiplied for large scale trials. About 2 maunds of seed were obtained from a crop of this type in an area of about one-fourth of an acre.

TOBACCO (*Nicotiana tabacum* L. AND *N. rustica* L.).

Observations on the F_4 of the cross between the white-flowered type 156 and the pink-flowered type 43 were continued. Some promising hybrids from this cross are undergoing curing trials. In connection with an experiment on the possible influence of the age at which fertilization occurs in flowers on the mendelian ratios in the progeny, flowers produced on a number of F_1 plants were selfed daily over a period of two months.

The large growings of type 142 tobacco for flue-curing this year produced a fine crop and some very good quality leaf was cured before the crop was damaged by a hailstorm on January 13th. Due to this it was not possible to save enough seed for distribution and numerous requests for seed of this hybrid tobacco had to be refused.

CHILLIES (*Capsicum annum* L. AND *C. frutescens* L.).

The original types were maintained. The work of isolating and fixing the Goa chillies was continued. Cultures which were segregating for fruit size and shape and hence very difficult to fix were rejected.

The F_2 generation of the cross, T. 3 \times T. 11A, was grown and segregation for anther colour was studied. type 3 has bluish purple anthers while the anthers of type 11A are yellow. The F_1 was intermediate for this character. In F_2 the ratio of individuals with purple anthers (of various grades) to those with yellow ones was 3 : 1, indicating a monohybrid segregation. A number of F_2 plants were selfed in order to grow an F_3 generation to confirm the F_2 results.

A new cross to study the inheritance of colour of unripe fruit (green : white) was made between type 1 and type 2.

A paper entitled "Studies in Indian Chillies. (4) The Inheritance of Pungency in *Capsicum annum* L." was written up and sent for publication.

HIBISCUS (*H. cannabinus* L. AND *H. sabdariffa* L.).

The original types were maintained. A few types of *H. cannabinus* L. received from Russia were also grown. These are very short in height and early in maturity and because of the former character are not expected to be useful from the economic view point. They can, however, be used for crossing purposes.

The F_1 generation of the cross between a type (T. 6) of *H. cannabinus* L. and a variety from Russia made in order to study the inheritance of plant height and maturity was grown. The first parent is very tall and takes about 80 days to flower while the second parent is very dwarf and takes only about 40 days to flower. The F_1 was intermediate for both these characters. About half a dozen of these F_1 plants have been selfed to provide seed for growing the F_2 generation.

The F_2 's of the crosses, New Hibiscus (*H. Sabdariffa* var. *altissima*) and *Albus* and New Hibiscus and *Ruber* were repeated in order to carry some red stemmed plants (of all grades), selected at random, to the F_3 generation to corroborate the previous F_2 results relating to the inheritance of stem colour.

Some promising fixed hybrids from the crosses, New Hibiscus \times *Albus* and New Hibiscus \times *Ruber*, were grown and specimens of a few of these were sent to the Fibre Expert to the Government of Bengal, Dacca, for preliminary fibre tests.

To investigate the effect of age of the F_1 plants on the mendelian segregation in F_2 a number of F_1 plants of two crosses of Hibiscus, New Hibiscus \times *Albus* and New Hibiscus \times *Ruber*, were made in the year 1931-32, and in the year following the F_1 was raised. The flowers on these F_1 plants were selfed, as they were produced, on each successive day. In the year under review the selfed seeds from these F_1 plants were grown separately date by date, and the segregation in the F_2 progeny thus obtained was studied. Two characters were considered, leaf-lobe, narrow or broad, and stem colour, red or green. The ratio of the dominant character to the recessive was calculated for each of these days, and it was found that the ratio did not show any periodical increase or decrease in either phenotype from day-to-day. The combined ratio for the total flowering period was in accordance with theoretical expectation. Unfortunately the population was rather small because of the poor germination occasioned by heavy rain falling immediately after sowing. It is proposed to repeat the experiment next season. Another set of F_1 plants was grown and the flowers selfed on successive days as in the previous experiment. A much larger quantity of seeds has been harvested this time.

LINSEED (*Linum usitatissimum* L.)

The 105 fixed hybrids and the 124 original types were grown. The latter were grown after a lapse of three years. Due to a bad attack of rust (*Melampsora Lini*) the seeds did not develop well and hence the intention of getting the oil content analysed and the seed size measured was abandoned.

Last year's yield trial experiment with seven hybrids and one standard type, type 12, was repeated and a preliminary yield trial with fourteen new hybrids and type 12 was also laid out in the form of "randomized blocks". Both these experiments were vitiated due to severe rust (*Melampsora Lini*) and it is proposed to repeat them next year.

The F_2 of the following crosses was grown and studied. T. 15 \times T. 12, T. 15 \times T. 20, T. 15 \times T. 22, T. 1 \times T. 24 and T. 4 \times T. 24. The dihybrid segregation for petal colour in F_2 in the crosses, T. 15 \times T. 12, T. 1 \times T. 24 and T. 4 \times T. 24, and the monohybrid segregation in the cross T. 15 \times T. 22 were confirmed. The F_2 of T. 15 \times T. 20 indicated that type 15 differed from T. 20 by two factors for petal colour, and that the bad fit in F_2 was due to the wrong diagnosis and grouping of different phenotypes. For instance one F_2 culture, from a culture noted down as T. 20 L (petal like T. 20 but lighter) segregated like F_2 although it was expected to segregate differently (1 T. 20 : 2 T. 20 L : 1 T. 15). The F_2 may have to be repeated.

The F_2 of the crosses T. 12 \times T. 24 and T. 21 \times T. 24 was grown and the segregation for petal colour was studied. In both the crosses a dihybrid segregation of 9 blue like F_1 : 3 blue like T. 24 : 4 blue like the other parent was obtained. A number of F_2 plants representing the different phenotypes has been selfed to carry to the F_3 generation for confirming the F_2 results.

An experiment to obtain an individual in which all colour factors are absent so that it could be used as a tester for types with unknown genetical constitutions has been started. When such an individual is isolated, it should be possible to ascertain the genetical constitution of any new type by crossing them together and growing the first generation only, thereby saving time, labour and land.

The bold-seeded Australian linseeds which are rather late for this part of India were sown about two weeks earlier than the usual sowing time. The seeds developed well and it is expected that a true idea of their oil yielding capacity will be obtained this year. The samples have been submitted for chemical analysis.

Besides the large seed-size these linseeds possess another good feature : they are immune to rust (*Melampsora Lini*). Some of these have been crossed with the high yielding indigenous types and fixed hybrids, with the object of combining in one type, high yield, high

oil content and resistance to rust. It is also hoped to study the inheritance of rust resistance.

SAFFLOWER (*Carthamus tinctorius* L.).

The original types were maintained. The selfed seeds of the variegated plants (arising out of the unselfed seed of T. 27) were grown and found to breed true. Attempts to cross this variegated plant with the normal green plant of the same type, T. 27, failed.

The F_1 plants of about six crosses between different types were grown and it was observed that the F_1 was intermediate for plant habit (spreading or erect) and maturity, as well as for spininess of leaf and bracts. Red and yellow colour of bud and flower were each dominant to white. A few F_1 plants of each of these crosses have been selfed for the F_2 study.

SESAMUM (*Sesamum indicum* D. C.).

The season was unfavourable for this crop and growth was poor. The study of the inheritance of certain characters in a cross between white-seeded and black-seeded types was continued. This cross has also an economic object, *i.e.*, the production of a high-yielding, white-seeded strain. White-seeded types are preferred by the trade as such types yield a lighter-coloured oil than the black-seeded types.

Brassicac.

The study of the self-fertilised types was continued. The report of the Royal Botanical Gardens, Kew, is being awaited to confirm the general classification of the different groups—both self-fertile and self-sterile.

The F_2 generation of the cross (yellow sarson No. 60-1-5 \times yellow sarson 26-8) was studied for the inheritance of flower colour and the number of pod valves. It was found that the segregation in flower colour is in the ratio of 3 yellow : 1 whitish yellow (creamy colour) and that the ratio of 2-valved pods : 3-4 valved pods is as 3 : 1. There is a good deal of variation in the recessive group but this is to be expected as the parental type with 3-4 valved pods itself shows considerable variation even in the same plant. The theory will be verified next year in F_3 .

The inheritance of pod habit was studied in the F_2 generation of a cross between 2 types of *Rai* (*B. juncea* Hooker). The ratio obtained was 3 adpressed : 1 open.

The study of the inheritance of the self-fertility and of seed colour was continued in the following crosses between types of

yellow sarson (*B. campestris* var. *sarson*, Prain), a self-fertile group with types belonging to the self-sterile groups :—

1. Black sarson late (*B. campestris* L. var. *oleifera* Prain) \times yellow sarson. F_4 .
2. Yellow sarson \times Black sarson late. F_3 .
3. Yellow sarson \times Burma sarson (*B. oleracea* var. *chinensis* Prain). F_2 .
4. Reciprocal of cross 3. F_2 .

The inheritance of self-fertility appears to depend upon multiple factors and the study will be continued next year. In seed colour, the blackish red colour of the self-sterile groups appears to depend upon more than 2 factors. This character also requires further study and the difficulties arise mainly because the self-sterile parents cannot breed pure.

TARAMIRA (*Brassica sativa* L.).

An experiment to study sterility was started in 1929-30. The essence of the experiment was to take four pairs of plants such that the individuals of each pair are similar as far as possible. The pairs consisted of the following plants :—

- (1) A & B.
- (2) C & D.
- (3) E & F.
- (4) G & H.

A was crossed with B, C with D and so on. Thus four different pedigrees and 8 strains were obtained. In the succeeding years effort was made to keep up these strains as long as possible, pollinating always between A and B and B and A and so on, and never between A and C, etc.

The strains were vigorous and appeared practically uniform in 1930-31. All strains except $C \times D$ and $D \times C$, died out as noted below :—

Strains $A \times B$ and $B \times A$ died out in the year 1931-32, and strains $E \times F$ and $F \times E$ and $G \times H$ and $H \times G$ died out in 1932-33.

The strains $C \times D$, $D \times C$ appear quite vigorous so far and are quite uniform and will be continued next year.

The above results show that some strains can tolerate close breeding for a longer time than others.

Statement showing the yield of crops in the Botanical Section in 1933-34.

Crop	Plot	Area in acres	OUTTURN OF GRAIN IN LB.		Remarks
			Actual	Per acre	
<i>Wheat—</i>					
P. 4 .	Inside Musahar 1 (part)	0.20	263.3	1316.5	
P. 4 .	Inside Musahar 2 (part)	0.32	761.1	2378.4	
P. 12 .	Inside Musahar 1 (part)	0.20	372.3	1861.5	
P. 12 .	Inside Musahar 2 (part)	0.32	674.8	2108.8	
P. 12-2	Inside Musahar 1 (part)	0.20	335.3	1676.5	
P. 52 .	Inside Musahar 4	0.65	1592.2	2449.5	
P. 101 .	Inside Musahar 3 (part)	0.32	827.0	2584.4	
P. 111 .	Inside Musahar 3 (part)	0.32	765.3	2391.6	
<i>Barley—</i>					
Type 21.	River bank East	0.76	2746.0	3613.5	Manured with 8 mds.ferm.cakes, Sown late after urid.
„ .	Barah 8 (part)	0.25	506.1	2024.4	
<i>Oats—</i>					
B. S. 1	S. T. G. 5	0.16	378.5	2365.6	
Hybrid C	Barah 1 (part)	0.05	133.8	2676.0	
„ .	Barah 7 (part)	0.14	401.1	2865.0	
<i>Lentil—</i>					
III-54 .	Orchard 1-A	0.48	148.1	308.5	Poor germina- tion.
<i>Gram—</i>					
T. 6 .	Pentagonal Border W.	0.13	84.4	649.2	Badly attacked by cut-worm.
T. 17 .	Farm Plot 1	1.00	1207.5	1207.5	
T. 17 .	Barah 4 (part)	0.182	111.1	610.4	
T. 25 .	Outside Musahar plots 1, 2, 3	0.88	1098.5	1248.3	
T. 28 .	Pentagonal Border E.	0.11	168.7	1533.6	
T. 41 .	Barah 4 (part)	0.182	156.4	859.3	
T. 58 .	Outside Musahar plots 4 and 5	0.56	629.5	1124.1	
T. 58 .	N. T. G. 10 (part)	0.11	107.0	972.7	

Crop	Plot	Area in acres	OUTTURN OF GRAIN IN LB.		Remarks
			Ac- tual	Per acre	
<i>Peas—</i>					
g. 14-1 .	S. T. G. 6 . . .	0.20	179.0	895.0	
<i>Rahar—</i>					
T. 15 .	½ River side (west) .	0.37	337.4	911.0	
T. 16 .	Pentagonal field .	0.40	389.8	974.5	
T. 24 .	½ River side (west) .	0.37	458.7	1239.7	
T. 41 .	Barah Border (part) .	0.056	94.6	1689.3	
T. 51 .	Orchard 2-D . . .	0.71	323.0	454.9	Was damaged badly by hail- storm.
T. 64 .	Pentagonal field (part)	0.21	288.0	1371.4	
T. 69 .	Orchard Border W. (part) . . .	0.036	64.0	1777.8	
T. 80 .	Pentagonal field (part)	0.41	353.8	862.9	
T. 82 .	" " " . . .	0.55	642.8	1168.7	

Statement showing the outturn of improved varieties of crops from the Botanical Section grown on Pusa Farm during 1933-34.

Crop	Plot	Area in acres	OUTTURN OF GRAIN IN LB.	
			Actual	Per acre
<i>Gram—</i>				
T 17 . . .	Gonhri . . .	4.00	2972.00	743.00
T 25 . . .	" . . .	5.00	2832.10	566.42
T 58 . . .	" . . .	4.00	2236.10	559.03
<i>Linseed—</i>				
T 124 . . .	Old Jhilli . . .	1.50	509.90	334.60
H 10 . . .	" . . .	0.50	96.70	193.40
H 55 . . .	" . . .	0.50	67.90	135.80
H 21 . . .	" . . .	0.50	105.90	211.80
H 68 . . .	" . . .	0.50	52.40	104.80
T 12 . . .	" . . .	1.20	454.60	378.83
T 121 . . .	" . . .	1.00	323.00	323.00
Russian Flax . . .	" . . .	0.30	37.00	123.33
<i>Lentil—</i>				
T 54 . . .	Old Jhilli . . .	1.00	664.50	664.50
T III-86 . . .	" . . .	1.00	695.30	695.30

Crop	Plot	Area in acres	OUTTURN OF GRAIN IN LB.	
			Actual	Per acre
<i>Oats—</i>				
Hybrid C . . .	Old Jhilli . . .	2.50	3072.80	1229.12
Hybrid J . . .	" . . .	2.50	3966.20	1586.48
B. S. II . . .	" . . .	1.50	2127.10	1418.07
<i>Wheat—</i>				
P 12 . . .	Mysore . . .	9.75	11157.70	1144.38
P 52 . . .	" . . .	9.75	13850.70	1420.58
P 4 . . .	S. Pangarbi . . .	11.00	5827.30	529.75
P 111 . . .	Nepali . . .	11.18	10072.60	900.95
P 101 . . .	" . . .	4.50	4260.40	946.75
<i>Barley—</i>				
T 21 . . .	B. F. 1 (30 ac. block)	10.00	11898.60	1189.86
<i>Arhar—</i>				
T 24 . . .	H. Jhilli (30 ac. block)	10.00	6697.50	669.75
T 51 . . .	" . . .	10.00	3438.50	343.85
T 15 . . .	Chheonia . . .	5.00	3676.10	735.22
T 80 . . .	" . . .	6.75	3761.00	557.19

MISCELLANEOUS.

The results of soil heterogeneity experiments conducted for three consecutive years in the same field at Pusa with barley, wheats and lentils respectively have been embodied in a paper sent for publication in the Indian Journal of Agricultural Science. It was found that there was a great deal of variation in the yields for columns and very little in the rows suggesting that there was a fertility gradient in this particular field which ran from west to east. Harris' method of determining soil heterogeneity and Fisher's analysis of variance method were utilised for this work and it was found that the former method provided only a measure of heterogeneity present in the field while Fisher's analysis of variance not only provided a measure of soil heterogeneity but also clearly set forth the direction of the fertility gradient and is therefore a more comprehensive method for such work.

A knowledge of the amount and direction of variability in the fertility of any experimental field helps in the proper lay-out of yield or manurial trials in the right direction and gives an indication of the shape and size of plot which ought to be employed. The combination which yields the least coefficient of variability within blocks in a preliminary trial is to be taken as the best one for laying out future trials in a field. The results obtained from two uniformity trials conducted in a particular field at Pusa have been employed to illustrate this fact and a paper on this subject has recently been sent in for publication.

III. PUBLICATIONS AND PROGRAMME OF WORK FOR 1934-35.

List of papers sent in for publication during 1933-34.

✓ Bose, R. D.—Some soil-heterogeneity trials at Pusa. *Ind. Jour. Agri. Sci.*

—————Size and shape of plot in field trials. *Ind. Jour. Agri. Sci.*

—————Studies in Indian Barleys. 3. Inheritance of resistance to *Helminthosporium sativum* P. K. and B. in two crosses between Pusa barleys. *Ind. Jour. Agri. Sci.*

✓ —————Studies in Indian Barleys. 4. Branched ears in barley and their mode of inheritance. *Ind. Jour. Agri. Sci.*

Deshpande, R. B.—Studies in Indian chillies. 4 The Inheritance of pungency in *Capsicum annum* L. *Ind. Jour. Agri. Sci.*

(Kashi Ram and Ch. V. Sarvayya.—The development of pigments in the glumes and apiculus of rice varieties. *Ind. Jour. Agri. Sci.*

—————The classification of the rice varieties of Bihar and Orissa. *Ind. Jour. Agri. Sci.*

✓ Khan, A. R. and Akhtar, A. R.—The inheritance of petal colour in gram (*Cicer arietinum* L.) *Agri. and Live-stock in India*. 4, 1934, 127—155.

✓ Pal, B. P.—Recent Progress in Plant-breeding at Pusa. *Agri. and Live-stock in India*.

Shaw, F. J. F. and Kashi Ram.—Improved varieties of crops produced at Pusa. *Agri. and Live-stock in India*.

PROGRAMME OF WORK FOR 1934-35.

Investigations will be continued on the genetics of those crops which have formed the subject of this report. Special attention will be given to yield trials and statistical methods. Fresh investigations will be started for the improvement of the potato crop and for the isolation of improved strains of sunn-hemp. Training of students will continue as in past years.

(2) REPORT OF THE BOTANICAL SUB-STATION, KARNAL.*(Financed by the Imperial Council of Agricultural Research.)***I. INTRODUCTION.**

Khan Sahib Abdur Rahman Khan held charge of the Station until his retirement on the 15th December, 1933; his retirement is a great loss to the Section and to the Department. From the 16th of December, 1933, to 11th of April, 1934, Mr. R. B. Ekbote was in charge of the duties of Superintendent in addition to his own. From the 12th April, 1934, Mr. Kashi Ram, Officiating Assistant Economic Botanist, Pusa, took over charge as Officiating Superintendent of the Sub-Station.

In the year under report the following amounts were realized mainly by the sale of the seeds :—

		Rs.	A.	P.
Cash credited into Karnal Treasury	.	3,581	5	6
Receipts adjusted by Book Transfer	.	515	7	7
Total	.	4,096	13	1

LAY-OUT AND CONSTRUCTION.

To facilitate carting of manure and farm produce a culvert on the road north of the General area was constructed and a certain amount of road levelling was done in the General area. As all the plots in the General area require levelling a block of 18·6 acres has been kept fallow for levelling during the coming cold weather. A threshing floor, bullock lines, and a *bhusa* shed are urgently required.

TRAINING.

The post-graduate students of the Botanical and Agricultural Sections, Pusa, visited this Sub-Station in March 1934, and they studied the following experiments with special reference to the growing of crops under canal irrigated conditions, practically similar to those of the vast areas of the Punjab and the United Provinces but quite unlike those of Pusa where all the crops are grown without irrigation.

- (1) The behaviour of Pusa selected *Brassica* types.
- (2) Barley yield trials.
- (3) Gram yield trials.
- (4) Experiments to elucidate the inheritance of characters in gram.
- (5) Oat yield trials.
- (6) Wheat yield trials.

The students of the Indian Dairy Diploma Course were given lectures on general elementary botany with special reference to agricultural crops.

A batch of students from the Agricultural College, Lyallpur, also visited the Station.

VISITS.

B. C. Burt, Esq., C.I.E., M.B.E., I.A.S., Agricultural Expert, Imperial Council of Agricultural Research; Dr. Hudson, Deputy Director, Bureau of Plant Genetics, Cambridge; Sir Jogender Singh, K.C.I.E., Minister of Agriculture, Punjab and the Director of Agriculture, Punjab, visited this Sub-Station during the year under report.

SEASON AND RAINFALL.

During the year under report *Brassica* and gram suffered a good deal from frost. Rains in March favoured the incidence of black rust (*Puccinia graminis*) on wheat so seriously that it reduced the crop yield much below the expectation.

Statement showing the rainfall at the Botanical Sub-Station, Karnal, in 1933-34.

June 1933	5·65	December 1933	0·09
July 1933	9·36	January 1934	1·21
August 1933	6·30	February 1934	0·36
September 1933	17·61	March 1934	1·73
October 1933	0·64	April 1934	0·10
November 1933 . . . . .	..	May 1934	0·20

Total rainfall = 43·25 inches.

• II. INVESTIGATIONS.

WHEAT.

Some of the new hybrids, between Pusa 4 and Federation and between Pusa 52 and Federation evolved at Pusa, could not attain their maximum development under the non-irrigated conditions and short growing season at Pusa. But when these hybrids were transferred to Karnal they did remarkably well though the types that did best at Pusa gave disappointing results when tried at Karnal. Hence, in order to test adequately the possibilities of the fixed hybrids, it is essential that they should be tested under as many different conditions as possible before they are finally selected or discarded. P. 120 is a hybrid between Pusa 52 and Federation. Its ear-head is compact, fully bearded, smooth glumed with red chaff. P. 165 is a hybrid between Pusa 4 and Federation. Its ear-head is lax, beardless, smooth glumed with white chaff. The hybrids P. 120 and P. 165 along with P. 4 and P. 12 were tested for yield

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together with C. 591 and 8A of the Punjab and C. 13 of the United Provinces. The yield trials were carried out both in Latin squares and randomized blocks. The results of one Latin square are given below in detail. Those for the other Latin square and the randomized blocks were very similar.

VARIETAL YIELD TRIAL.

WHEAT.

Comparison of varieties.—P. 165, P. 120, C. 591, C. 13, P. 4, P. 12, Punjab 8A.

Yield of grain in lb. per plot.

P. 120 27.1	P. 165 30.4	C. 591 17.4	8A 14.6	P. 4 13.0	P. 12 7.7	C. 13 10.0
8A 14.4	C. 591 16.1	P. 4 13.4	C. 13 6.6	P. 12 7.3	P. 120 19.6	P. 165 27.1
P. 165 33.4	8A 12.4	C. 13 6.5	P. 12 9.5	C. 591 19.9	P. 4 12.4	P. 120 21.7
C. 591 20.4	C. 13 10.2	P. 120 19.9	P. 4 11.1	8A 9.3	P. 165 27.1	P. 12 7.1
P. 12 11.9	P. 4 15.7	P. 165 27.6	C. 591 14.6	P. 120 22.1	C. 13 9.8	8A 11.8
P. 4 18.2	P. 120 19.9	P. 12 10.0	P. 165 28.9	C. 13 5.9	8A 11.2	C. 591 18.7
C. 13 14.1	P. 12 12.8	8A 12.3	P. 120 19.9	P. 165 29.4	C. 591 16.2	P. 4 15.1

System of replication.—Latin square (7 × 7).*

Area of each plot.—15' × 46' or 1/63.13 acre.

Summary of results.

	MEAN YIELD IN LB.							General mean.	S. E. of treatment mean	Significance of 'Z' test	Critical difference for significance (in lb. per acre)
	P. 165	P. 120	C. 591	C. 13	P. 4	P. 12	Punjab 8A				
Per acre	1838.8	1354.6	1112.8	568.8	891.8	598.6	776.8	1019.9	44.4	Significant.	172.5 at 1 per cent. level 128.1 at 5 per cent. level
Per cent. on general mean.	180.2	132.7	109.0	55.7	87.4	58.7	76.2	100	4.34		

Conclusions :—P. 165 > P. 120 > C. 591 > P. 4 = Punjab 8A > C. 13 = P. 12 at 1 per cent. level.

The yield tests for all the above noted wheats were also simultaneously carried out at several Agricultural Stations in collaboration with the Directors of Agriculture of the Punjab and the United Provinces in their respective Provinces. The results from all those places are still awaited.

Besides the two hybrids, viz., P. 120 and P. 165 several other hybrids were also under observation. In order to test their yielding capacity some of the promising ones will be multiplied in the following season.

A large part of the total area of the Sub-Station was under seed multiplication. The demand for pure seed is steadily increasing, and it was not possible to supply more than 25 per cent. of the demand this year. The quantity of seeds distributed from this Sub-Station is shown in a statement at the end of this report.

P. 80-5 on account of its stiff straw did not lodge and remained comparatively free from black rust as well. This wheat was much in demand by the Punjab Agricultural Department.

P. 114 stood remarkably well against the severe incidence of black rust and loose smut.

An experiment in collaboration with the Imperial Mycologist, Pusa, to test the effect of ceresan, copper carbonate, formalin and uspulun (universal) in controlling bunt of wheat was started last November. There were eight replications for each treatment. All the ears in various plots were examined for bunt and the percentage of bunt was determined. The crop was harvested and the number of plants and the number of ears in each plot were counted and the weight of grains taken.

From the results it appears that none of these treatments is altogether effective in controlling the disease though the percentage of diseased ears is reduced. Uspulun (universal) appears to have done comparatively better than other treatments. The only partial success of these treatments is due to the presence of mycelium in the grain. The only fully effective method by which both loose smut and bunt can be controlled is by hot water treatment.

BARLEY.

An yield trial with five Pusa types together with two types from the Punjab known as L. 4 and L. 5 was laid out and the following results were obtained.

BARLEY YIELD TRIAL.

Comparison of varieties.—T. 4, T. 13, T. 16, T. 18, T. 21, L. 4, L. 5.

Yield per plot in lb.

L. 5 40·00	L. 4 29·00	T. 18 45·00	T. 16 39·00	T. 21 28·75	T. 13 41·00	T. 4 34·25
T. 18 41·00	L. 5 39·50	T. 4 33·50	T. 13 45·75	T. 16 37·00	L. 4 23·25	T. 21 32·75
T. 16 41·00	T. 18 38·00	L. 4 27·25	T. 21 33·00	T. 4 28·00	L. 5 38·50	T. 13 37·00
T. 13 44·75	T. 16 42·25	T. 21 35·625	L. 4 17·25	T. 18 32·00	T. 4 26·00	L. 5 42·00
T. 4 32·75	T. 21 38·50	L. 5 36·25	T. 18 35·75	T. 13 32·00	T. 16 24·75	L. 4 14·00
T. 21 33·50	T. 4 33·25	T. 13 44·25	L. 5 41·75	L. 4 19·00	T. 18 34·00	T. 16 31·75
L. 4 30·50	T. 13 43·75	T. 16 38·25	T. 4 36·00	L. 5 41·75	T. 21 35·75	T. 18 35·75

System of replication.—Latin square (7 × 7).

Area of each plot.—13' × 48' or 1/69·81 acre.

Summary of results

	MEAN YIELDS IN LB.						S. E. of Treat- ment mean	'Z' test signifi- cance	Critical differ- ence (lb. per acre)
	T. 13	L. 5	T. 18	T. 16	T. 21	T. 4	L. 4		
(1) Per acre	2877.09	2789.83	2607.81	2533.03	2372.21	2231.37	1598.08	87.41	5 % = 252.36 1 % = 339.88
(2) % on general mean	118.43	114.84	107.35	104.27	97.65	91.85	65.78	3.60	@ 5 % = 10.39, @ 1 % = 13.99.

Conclusions. T :—13 = L. 5 > T. 18 = T. 16 = T. 21 > T. 4 > L. 4.

OATS.

An yield trial with 13 hybrids replicated five times in randomized blocks, similar to that of the previous year, was conducted. The results are given below :

OATS YIELD TRIAL

Comparison of types and hybrids (B. S. 1 (M), B. S. 2 (L) and hybrids A-K.)

Yield per plot in pounds.

Varieties Blocks	A	B	C	D	E	F	G	H	I	J	K	L	M
I	16-7500	11-2500	16-1250	16-1875	14-2500	14-3750	14-8750	14-1250	14-8125	15-6875	16-5000	16-5000	16-9375
II	15-2500	11-0625	16-1250	13-4375	14-7500	13-9375	16-0625	12-8125	16-9375	15-7500	13-6250	14-6875	20-8750
III	16-5000	14-1875	17-6875	20-0625	18-3125	18-1250	17-4375	15-7500	17-1250	16-3750	14-9375	18-8750	20-7500
IV	19-0000	13-0000	17-5625	15-3125	20-3750	19-4375	20-0625	16-5000	20-3750	20-7500	16-8750	22-2500	23-7500
V	23-3750	15-7500	24-1250	20-9375	22-1250	22-0625	22-9375	18-0625	21-3750	19-6875	22-5625	19-3750	23-6250

System of replication.— Randomized blocks (13 × 5).
Area of each plot.—60' × 7'.

PADDY.

In Upper India generally and especially at Karnal, the so-called autumn paddies are largely grown. The crop is often followed by some *rabi* cereals or legumes. Non-shedding, high yielding, early ripening varieties with thin long-grained rice are much in demand. In order to pick out suitable kinds from the types isolated a preliminary yield test was conducted. This trial resulted in four promising varieties being selected. A proper yield test with these four kinds along with other two types from Pusa will be carried out in the following season.

The isolation of types is practically over now. The characters under study are going to be finally checked in the coming season. The classification of paddy types has been based on qualitative characters, on similar lines to the classification employed at Pusa.

GRAM.

Yield trials.—An yield trial with gram Type 17, Type 28, Type 58 and Local was repeated in randomized blocks with 12 replications. The results, however, have shown that the yield differences are not significant. This year gram sowing was delayed due to rains and in January frost did a good deal of damage. The trial, therefore, will be repeated in the course of the next season.

The demand for gram seed this year was considerable and could not be met in full.

Gram crosses.—The inheritance of floral characters has been studied fully and the results have already been published in *Agriculture and Live-stock in India*, Vol. IV, Part II, 1934.

Attention is now concentrated on the study of seed characters such as colour, shape, size and surface, and with this aim in view, the following crosses were grown during the year under report.

- | | |
|-------------------|------------------------------|
| (1) T. 35 × T. 2 | } F ₂ generation. |
| (2) T. 39 × T. 2 | |
| (3) T. 39 × T. 2 | } F ₃ generation. |
| (4) T. 52 × T. 11 | |
| (5) T. 21 × T. 11 | |
| (6) T. 82 × T. 1 | |
| (7) T. 12 × T. 11 | F ₄ generation. |

Seed colour in gram varies a good deal and some times the range of variability is so wide as to render sorting of phenotypic classes somewhat difficult. While in some crosses inheritance of colour and shape of seed is simple and clear, in others complicated segregation has been observed.

(1) Type 35 × Type 2. In this cross both the parents are white flowered. Type 35, however, has orange coloured and perfectly

round seeds and Type 2 has white and less round seeds. F_1 seeds were intermediate between orange and white, more like Type 2 and round like the Type 35 parent. In F_2 a ratio of 2 intermediate : 1 white like Type 2 has been realised. Seed shape inheritance, however, seems to be less simple. It was observed that round seeds like Type 2 formed 9/16th and those like Type 35, 7/16th of the total. The results will be confirmed in F_3 which will be grown next year.

(2) Type 39 \times Type 2. In this cross parent Type 39 has pink flowers while Type 2 is white flowered. In F_1 the flower colour was pink and in F_2 a ratio of 3 pinks : 1 white was observed. As regards seed, Type 39 is yellowish pink and irregular while seeds of Type 2 are white and somewhat round. F_1 seeds were more or less like Type 39 in colour and irregular in shape. In F_2 , besides the seeds of parental types and those like F_1 , new forms such as deep red, orange and fawn have appeared. It seems that the seed colour in this cross is determined by more than two factors.

(3) Type 82 \times Type 1. As in the above cross, the F_2 results indicated a trihybrid segregation. The F_3 is being studied at present.

(4) Type 52 \times Type 11. All crosses with Type 11 have given clear segregations and the F_3 observations have borne out the F_2 results. Type 52 is pink flowered with yellowish brown and irregular seeds. Type 11 has white flowers and bluish brown and round seeds. In F_1 the flower colour was pink and seeds were yellowish brown and irregular like the Type 52 parent. In F_2 the following segregation as regards seed colour and shape was observed :—

	Observed	Expected on 3 : 1 ratio.
Yellowish brown irregular	39	41.25
Bluish brown round	16	13.75
Total	55	55.00

Dev. = 1.04
P. E.

Fit is good.

It is thus evident that yellowish brown colour and irregular shape are dominant over bluish brown and round seeds and that a one factor difference is responsible.

It will, however, be interesting to consider seed colour and shape in relation to flower colour. In F_2 a ratio of 9 pink : 3 blue : 4 white flowered plants was observed.

Flower colour	Pink .	Blue .	White.	
Seed colour	Yellowish brown.	Bluish brown.	Yellowish brown.	Bluish brown.
Seed shape	Irregular	Round .	Irregular	Round.
Observed	31	12	8	4
Expected on 9 : 3 : 3 : 1 ratio .	30.93	10.31	10.31	3.44

$\chi^2 = 0.8995$

Fit is good.

The observations in F_2 confirm the above results. It will thus be seen that all pink flowered plants produce yellowish brown and irregular seeds, blue, bluish brown round seeds, while in white flowered plants one-third produce bluish brown round seeds and two-thirds yellowish brown and irregular seeds. The factors responsible for flower colours also influence seed colour and shape. It is assumed that factor B is responsible for blue colour in flower and bluish brown round seeds. Factor A has a similar action on seed like B but does not influence flower colour. Factor P modifies blue flower colour to pink and bluish brown and round seeds to yellowish brown and irregular. Type 11 has only A, since its flower is white and seeds are bluish brown round. Parent Type 52 has all the three factors, viz., A, B and P. P and B being present the flower is pink and seeds yellowish brown and irregular. In F_2 factors B and P segregate and give the ratio mentioned above.

(5) Type 21 \times Type 11. The results of this cross too are clear though one factor in addition to the three described above has been found to interact. As regards flower colour the results are exactly similar to cross Type 52 \times Type 11. Type 21 has dark reddish brown seeds and when crossed with Type 11 gave in F_1 dark reddish brown seeds and in F_2 a ratio of 9 dark reddish brown to 3 yellowish brown to 4 bluish brown seeds. The relation of flower colour to seed colour observed in cross Type 52 \times Type 11 holds good. All pink flowered plants give 27 dark reddish brown : 9 yellowish brown seeds, all white flowered plants 9 dark reddish brown : 3 bluish browns : 4 yellowish brown seeds; and all blue flowered plants possess only the bluish brown and round seeds. The segregation is trihybrid and can be explained on the assumption that in addition to factors A, B, P, Type 21 has a factor D which modifies yellowish brown seed to dark reddish brown.

(6) Type 12 \times Type 11. This cross has presented the least difficulty. Both the parents are white-flowered. Type 12 has

reddish brown irregular seeds. In F_1 the seeds were somewhat reddish brown and in F_2 a simple ratio of 3 reddish brown irregular : 1 bluish brown round seeds was realised. The F_2 behaviour was subsequently confirmed in F_3 generation.

In addition to colour and shape of seeds, seed surface and presence and absence of black dots on seed coat were also studied and both behave as mendelian characters. The detailed results of all these characters will be submitted for publication later.

BRASSICA.

Cultures.—Many cultures representing different species of Brassica were grown and observations on the morphological characters as a step to classification have been taken and compared with those recorded in the previous year. Specimens of these cultures were sent to Kew gardens by the Imperial Economic Botanist, Pusa, for identification. A provisional identification has been done but the enquiry will be complete only after examining fresh material which is being raised from seeds sent from Pusa.

Crosses.—The inheritance of seed colour, self-fertility and root thickness was studied. The details are given below :—

(1) *Cross.*—Yellow sarson 75-1 \times Toria 48-1 F_2 .

Number of F_1 plant	Red seeds	Yellow seeds	Total
1	37	16	53
3	25	9	34
4	26	20	46
Total observed	88	45	133
Expected on 3:1 ratio	99.75	33.25	
Dev. = 3.49 P. E.			
Fit is bad.			

(2) *Cross*.—Toria 48-1 \times Yellow sarson 60-1-5 F_2 .

Number of F_1 plants	Red seeds	Yellow seeds	Total
1	6	2	8
2	18	6	24
3	13	2	15
4	23	5	28
5	12	1	13
Total observed	72	16	88
Expected on 3:1 ratio	66	22	88

Dev. = 2.2

P. E.

Fit is good.

(3) *Cross*.—Yellow sarson \times Black sarson F_2 .

No. of F_1 plan	Red seeds	Yellow seeds	Total
1	10	1	11
2A	26	7	33
2B	57	15	72
3	4	0	4
5	18	2	20
7A	2	2	4
7B	16	9	25
12	22	2	24
22	21	5	26
Total observed	176	43	219
Total expected	164.25	54.75	

Dev. = 2.7

P. E.

Fit is good.

It will be seen that the frequency of the yellow seeded phenotype is in excess in cross No. 1 while in the rest it falls below the expected numbers. The population is limited due to heavy casualties as a result of frost and hence if seed colour is controlled by more than one factor, chances of realising the recessive phenotype, viz., the yellow seeded class are reduced.

The inheritance of root thickness was studied in a cross, Turnip \times Yellow sarson 60-1-5. Yellow sarson has a thin tap root while

turnip root is bulging. The F_1 root was intermediate in thickness. In F_2 the following segregation was observed :—

F_1 plant number	Root like turnip	Root intermediate	Root like yellow sarson	Total
1	5	38	19	62
4	21	135	55	211
Total observed	199		74	243
Expected on 3 : 1 ratio	204.75		68.25	243

Dev.

P. E. = 1.2

The fit is good.

During the course of study it was easier to distinguish roots like yellow sarson than those like turnips from intermediates. Hence the frequency of sarson-like roots is considered against the total of intermediate and turnip-like roots.

INHERITANCE OF SELF-FERTILITY.

It was intended to study the inheritance of this character in a large population and with this aim in view 400 plants were bagged in all. The season was, however, most unfavourable for study of this character. Due to heavy frost, setting of seed even outside the selfing bags was greatly hampered. The result was that out of the population of 400 only a small number of plants could be studied.

The results though incomplete suggest that a unit factor is responsible for the difference and that self-fertility is dominant.

III. SEED DISTRIBUTION.

The following statement shows the quantity of seeds distributed during the year 1933-34 :—

Crop		Quantity of seed distributed in lb.	Total
Wheat Pusa	4	12194.8	42457.5
" "	12	8640.0	
" "	80.5	13381.7	
" "	111.	1902.9	
" "	112.	617.1	
" "	113.	658.3	
" "	114.	1306.3	
" "	120.	2320.5	
" "	165.	1435.9	
Gram Type	17	3702.9	6953.1
" "	58	3250.2	

IV. YIELDS OF CROPS.

Statement showing the crop returns of the Botanical Sub-Station at Karnal for 1933-34.

Area	Plot No.	Crop	Area in acres	Actual yield in lb.	Calculated outturn per acre in lb.	Bushel weight in lb.
General—	29—34	Gram T. 17	8.33	11637.3	1397.03	
	28	T. 28	1.84	2797.7	1520.49	
	24—27	T. 58	8.54	16794.6	1966.58	
	35—41	Wheat P. 4	15.50	10806.2	697.17	56.2
	44—51	P. 12	12.58	7656.7	608.64	52.0
	17—23	P. 80—5	16.47	16560.1	1005.47	64.8
	6—13	P. 111	9.71	7191.8	740.66	64.8
	14	P. 112	1.37	968.9	707.23	64.7
	15	P. 113	1.41	1082.1	767.45	64.1
	1—5	P. 114	4.63	5091.4	1099.65	64.9
	42	Oats Hy. J	3.18	5136.7	1615.31	29.6
	43	B. S. 1	1.0	1656.0	1656.0	31.7
Experiment- al—	15—16	Wheat P. 120	2.55	4198.7	1646.55	61.20
	13—14	P. 165	2.26	4754.1	2103.60	63.86
Rice	3 a	Paddy A	.30	432	1440	
		B	.33	432	1309	
		C	.32	310	969	
		D	.33	308	933	
		E	.32	370	1156	
		F	.32	473	1478	
		G	.32	372	1162	
		H	.43	391	909	
		J	.27	247	915	
		K	.24	175	729	
		L	.52	376	723	
Building	1	M	.26	144	554	
		Toria local	.41	730	1780	

REPORT OF THE SUGARCANE EXPERT.

(RAO BAHADUR T. S. VENKATRAMAN, B.A., I.A.S.)

I. CHARGE AND STAFF

I held charge of the office of the Government Sugarcane Expert throughout the year except for one month's absence on leave in September 1933, when the Second Cane Breeding Officer, Mr. N. L. Dutt, M.Sc., held charge. The Second Cane Breeding Officer was absent on leave till 3rd August 1933 and during the period Mr. M. K. Krishnaswami, M.A., his senior Assistant, held charge of duties of Second Cane Breeding Officer in addition to his own. Mr. G. V. James continued to be in charge of the Sub-station at Karnal throughout the year.

With the help of funds kindly sanctioned by the Imperial Council of Agricultural Research, the staff at the Station was strengthened by the appointment of a Sugarcane Geneticist and Dr. Miss E. K. Janaki-Ammal, M.A., M.Sc., D.Sc., F.L.S., joined the post on the 25th May 1934.

II. SUGARCANE BREEDING (MAINLY SUB-TROPICAL TYPES)

(a) BREEDING TECHNIQUE

(i) *Controlling time of arrowing.*—The planting of canes at different seasons and under different soil conditions synchronised their times of arrowing to such an extent as to enable effecting of crosses not possible hitherto. A modified form of topping—concentrating on the side shoots—was started with the object of further influencing time of arrowing.

(ii) *Isolation of arrowing canes.*—The Coimbatore method of isolation of arrowing sugarcanes in tile pots for purposes of hybridization—which had proved so useful in the past—was further simplified by Mr. R. Thomas, who obtained equally good results by isolating the canes in water culture and in earthen pots.

(b) THE BREEDING PROGRAMME

The arrowing during the season was normal and satisfactory; and this enabled the carrying out of the programme laid down for the year more or less fully, so far as the breeding of economic types was concerned. Certain of the trial crosses had, however, to be postponed owing to the disparity in the times of arrowing of the parents, which had not been specially planted for the purpose.

The economic bulk crosses included six combinations, three of them being made for supplying seedlings as seedlings to the Sub-station at Karnal and the Sugarcane Research Station at Shah-jahanpur. The parents employed in these bulk crosses were mostly Coimbatore canes of proved utility such as Co.'s 213, 244, 281, 285, 290 and 313. Six trial combinations were made to pick out the most promising of them for the bulk crossing of economic type during subsequent years. Nine combinations—involving types of *Saccharum spontaneum* or *Sorghum*—were effected in connection with cytological studies of the genus *Saccharum*. During the season about a lakh and a half of seedlings were raised of which about half were planted in the first ground nurseries. These were thinned down to about 18,000 while planting in the second ground nurseries for a full year study.

(c) NEW PARENTS

Certain of the hybrids between P. O. J. 2725 and various types of *S. spontaneum*—originally raised for academic studies—showed distinct promise of use as parents on account of their health and good tillering power. These were, therefore, added to the plot of parents at the station. Other new parents thus added during the year included three of the hybrids between P. O. J. 2725 and *Sorghum Durra* Stapf raised in the year 1930. These hybrids, which showed little healthy pollen in the first year, are now producing a fair amount of such pollen and setting seed freely as well. As the resultant seedlings showed satisfactory vegetative and juice characters the above hybrids have also been added to the collection of parents.

(d) SELECTION OF USEFUL TYPES

Of the 126 seedlings under test in rows during the year seventeen were raised to the status of Co.'s on data obtained from periodic root and shoot studies and juice analysis. These studies have revealed interesting differences between varieties in the manner by which the tonnage at harvest is built up during the different stages of growth. Whereas in certain cases the full growth of cane is laid fairly early in the ripening season, in others the process would appear to be continuous during the ripening period. The selections include five 'early', three 'medium' and nine 'late' maturing types. The outstanding 'early' types include one seedling obtained by selfing Co. 214 which is itself an early maturing cane; the second is a hybrid between P. O. J. 2725 and *Sorghum Durra* Stapf.

III. RESEARCH AND INVESTIGATIONS.

(1) *Studies in germination*.—Quick and vigorous germination being a most desirable character in a new cane, work was started

by the Assistant Sugarcane Expert, Mr. K. Krishnamurthi Rao, on possible correlations and devising means to improve germination in the field. Promising results have been obtained both from topping canes in the field and soaking the setts previous to planting. The data obtained confirm the previous finding at the station that, in a three budded sett, the central one germinates the quickest and the best.

(b) *Effect of arrowing on juice quality.*—Periodic juico analyses of arrowing canes by Mr. K. V. Gopala Iyer, B.A., showed that improvement in both sucrose and purity is possible long after the arrows are out—as much as two months in certain cases. While it is true that in the same field the arrowed canes show slightly higher sucroses and purities than non-arrowed ones, the arrowing by itself is not a sign of cane maturity.

(c) *Cytological studies.*—A certain amount of new ground in sugarcane cytology was covered during the year through the enthusiastic work of Mr. T. S. N. Singh, B.Sc. largely on material carefully preserved and planted from year to year for over a decade by Mr. R. Thomas. Chromosome countings were made not only of the different types of *S. spontaneum* and of *Saccharum munja* but also of the various inter-specific and intergeneric hybrids available at the station. Certain of the results obtained and since published have been confirmed by a recent publication by Dr. C. Bremer till recently and for long the cytologist at the Sugarcane Experiment Station at Pasoeroean in Java. The *Sorghum* hybrids would appear to contain at least two groups—one in which there is a doubling of chromosomes on the mother side at *Karyokinesis* and the other where there is no such doubling.

(d) *Saccharum spontaneum types.*—A tour in Bihar by Mr. R. Thomas with the active help and full co-operation of the Bihar Department of Agriculture—through Mr. D. R. Sethi, the Director and Mr. K. L. Khanna, the Sugarcane Specialist—has resulted in the addition of eight new types to the collection of *S. spontaneums* at the station. One hundred seedlings from most of the types are growing in the plots for morphological and cytological studies. A form from Burma is easily outstanding on account of its great tillering power, but its arrowing is neither steady nor abundant.

(e) *Soil types to suit different canes.*—A cheap and simple method was devised to get indications about the kind of soil best suited to particular canes. Briefly stated the method consists in growing the plants above and away from the soil by an arrangement previously evolved at the Station and developing a definite number of shoot roots from a node well above the soil level. An equal number of these roots are now made to grow and develop in different pots each containing one of the soils under test. Data thus obtained have largely corroborated the recorded experience with different

canes ; and Mr. S. A. Hussainy has made himself responsible for an extensive study on these lines.

(f) *Sugarcane-Sorghum hybrids*.—The rather extensive series of these crosses between Sugarcanes and *Sorghum* mentioned in the last report yielded a certain number of selections, some of which were characterized by high sucrose and purity percentages. The combinations with Coimbatore canes gave, on the whole, better types than that with P. O. J. 2725.

F₁ hybrids between P. O. J. 2725 and *Sorghum Durra* Stapf crossed with the *Sorghum* male parent, yielded a rather interesting series. Besides plants which showed very obvious traces of the *Sorghum* parent, the series included certain peculiar types which showed rather continuous flowering and thick coriaceous leaves very dissimilar to those of either Sugarcane or *Sorghum*. (Plate II, fig. 1.)

IV. RESEARCH AND INVESTIGATIONS BEARING MAINLY ON THICK CANE BREEDING

(N. L. DUTT, M.Sc.)

(a) BREEDING.

An important feature of the hybridization programme during the year was the further utilization of certain of the hardier medium Coimbatore canes as one of the parents, viz., Co. 205, Co. 243, Co. 244, Co. 285 and Co. 290. This was done because canes like Co. 402, Co. 408, Co. 413, Co. 417 and Co. 419—which contain the blood of the hardier types—are proving a success in the preliminary trials at the various Experiment Stations in India. The following crosses were, therefore, made on a bulk scale :—

(1) *Vellali* × Co. 243, (2) P. O. J. 2725 × Co. 243, (3) P. O. J. 2878 × Co. 290. Other combinations which are expected to yield good seedlings are Co. 419 × Co. 244 and Co. 411 × Co. 243.

One of the problems in the breeding of the tropical types for India has been to breed varieties that will resist wind and cyclones. Some success was obtained in this direction as the majority of the seedlings in the cross Co. 408 × Co. 413 have the needed habit with short erect canes. (Plate II, fig. 2.)

(b) SELECTION

The selection of suitable thick type of canes has now reached an important stage as the satisfactory growth of recent distributions has enabled the setting up of standard types for the various tracts. Accordingly 15,000 seedlings, which had been raised from seed, and had completed their full growth in the field were studied and 210 of them as conformed to the standard types in growth and

PLATE II



Fig. 1. One of the many curious types obtained from the combination (P⁺ O⁻ J⁻ 2725 X *Sorghum Durra* Stapf) X *Sorghum Durra* Stapf. The plants are much stunted in growth and possess short thick coriaceous leaves very dissimilar to those of either the angustate or *Sorghum* parent.

PLATE II—continued

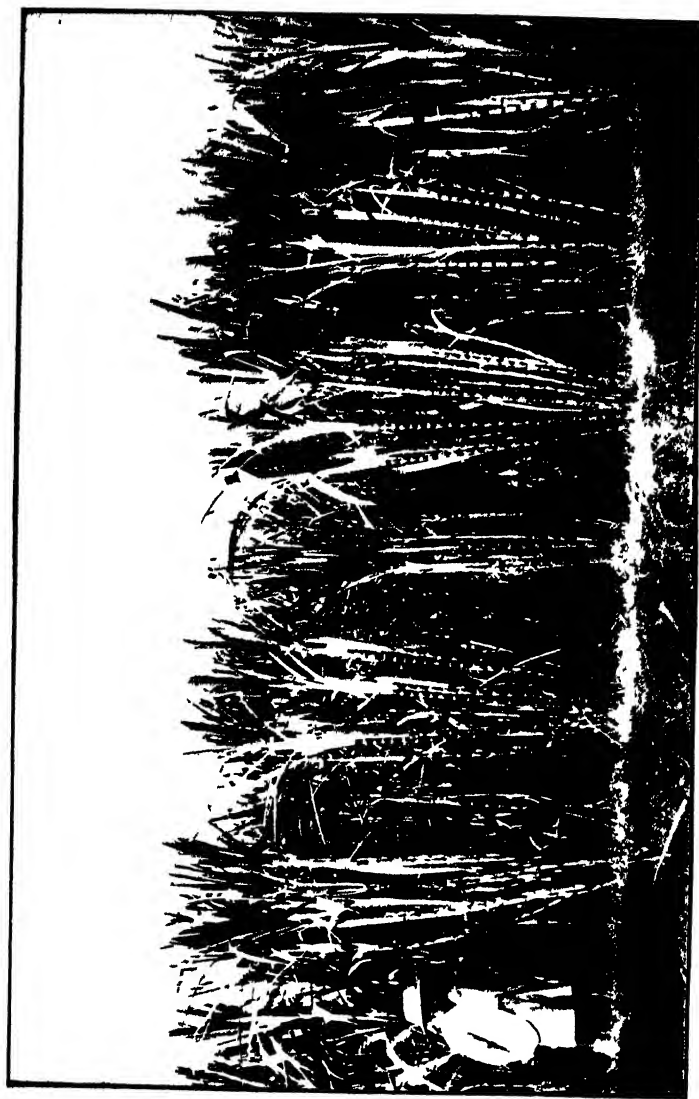


Fig. 2 The cross Co. 408 X Co. 415 yields seedlings with short erect canes a type likely to be useful in the breeding of canes to resist wind and cyclones. The above shows a plot of seedlings from this combination

sucrose percentage were selected for further testing. Similarly eleven seedlings from the final test plots were selected after comparing their yields with the standards and were raised to the status of Co.'s during the year. Their parentages are given elsewhere in the report.

(c) CHARACTERISTICS OF CERTAIN THICK CANE SEEDLINGS

It is proposed to study definite characteristics of such thick cane seedlings as show promising growth in various Experiment Stations. During the year observations were, therefore, made on the late-ripening quality of Co. 402. This cane is a fairly heavy yielder and is at the same time relatively non-flowering. It is unimpressive in the early stages of its growth, but pulls up later and finishes as a good yielder. It is, however, a full eleven to twelve months cane and capable of standing in the field without significant deterioration upto thirteen to fourteen months. Rao Sahib B. P. Vagholkar, Principal Agricultural Officer, Padegaon Sugarcane Research Station (Bombay Presidency), reports that this cane has done "exceptionally well". It is, therefore, likely to find favour for making jaggery with such ryots as are accustomed to growing green or yellow coloured noble canes like *Pundia*, *Poovan* or *Vellai*, while for factories its chief attraction will be that it can be crushed late. The following table gives analyses of a few rows of this variety which were left over un-harvested after the fourteenth month.

TABLE I

Fortnightly analyses of Co. 402 from the fourteenth month onwards in Field No. 7. (Planted on 12th February 1933)

Date of analyses	Brix Per cent.	Sucrose Per cent.	Co-efficient of purity
5th April 1934	17.60	15.49	88.0
20th April 1934	17.55	15.46	88.1
5th May 1934	15.37	13.54	87.0
21st May 1934	14.49	12.57	88.4
5th June 1934	16.44	14.06	85.5

(d) MORPHOLOGICAL STUDY OF THICK CANES

Some attention was devoted to the study of morphological characters of thirty varieties of the noble or thick type grown in India. These have been tentatively assigned to various groups and a few points still remain to be cleared up. These have been planted according to groups to facilitate observations *en masse*.

(e) CYTOLOGICAL STUDIES

Botany Assistant, Mr. K. S. Subba Rao, B.A., continued his studies on chromosomes in noble canes as also on fertilization and embryogeny with interesting results.

Mr. Rao has investigated six more varieties including *Kaludai Boothan*, *Striped Mauritius*, and *Badila (Fiji B)*. He has also fixed material for the study of the morphology of chromosomes, a necessary complement to the study of morphological characters of varieties.

Further progress was made with regard to fertilization studies. In the cross P. O. J. 2725 \times *Glagah*, a sperm nucleus was noticed near the egg nucleus five hours after pollination. This shortens the time taken by the pollen tube to reach the embryo-sac by about two hours from the previous record of seven hours. Sugarcane varieties differ in the rate of growth of their pollen tubes in artificial culture and the time taken by the pollen tubes to reach the embryo-sac probably varies with the pollinating parent.

During the course of the study of embryogeny a few cases of the abnormal position of the egg were noticed. In one of the preparations the egg was near the antipodals, while in another two eggs were noticed, one at each end of the embryo-sac.

A case of polyembryony has already been recorded in one of the previous reports. That was noticed in one of the microtome sections and attempts have since been made to see whether the same phenomenon occurs in the actual germination of seeds. In the seeds collected from the cross Co. 400 \times Co. 205 two independent plumules and radicles were noticed coming from one and the same seed.

(f) CONTROLLING TIME OF ARROWING

Canes of Co. 290 were subjected to six hours day light. These flowered twenty-six days earlier than the controls. The pollen, however, gave only one per cent. germination when cultured artificially.

The experiment on "Topping" was conducted on a somewhat larger scale than in previous years. Canes of P. O. J. 2878 were 'topped' twice and flowered eleven days later than the controls. This enabled their crossing on a bulk scale with Co. 290. The germination of the seeds was satisfactory.

(g) POLLEN STUDIES

An interesting observation made during the course of the pollen studies was that in the artificial cultures the pollen grains in crowded portions germinated much better than where the grains were scattered, indicating some effect of massing.

In working with a crop like sugarcane the principle operations such as crossing, study of flowering habits, pollen viability, etc., have to be crowded in in a period of about two months, and when for a single item like pollen germination, over 300 cultures have to be gone through, any method which will help in taking up the cultures at leisure will be an advantage. Unless the cultures are examined on the same day or at the utmost on the next day, fungal growths appear and besides, the contents of the burst tubes and grains render the making of observations a difficult task. Botany Assistant, Mr. M. K. Krishnaswamy, M.A., has devised a method by which the cultures in petri dishes can be examined even after about a fortnight. He tried form-acetic-alcohol but with not much success, as dessication and consequent bursting of grains and tubes set in. If, however, a few drops of formalin are added to the bottom dish it keeps the pollen tubes intact and also prevents growth of fungi.

(h) GERMINATION IN THICK CANE SEEDS

Experiments were continued on the comparison of *Vellai* with two of its seedlings, viz., Co. 400 and Co. 403 for seed germination when the same pollinating parent was employed. Equally weighed quantities—three grms. per seed pan—were sown. The parentage of Co. 400 is *Vellai* × Q. 813 and of Co. 403 is *Vellai* × Co. 243. The male parents used were E. K. 28 and Co. 205. The germinations obtained are given in Table II.

TABLE II

Germination per pan

	10 days	20 days	30 days
<i>Vellai</i> × E. K. 28 . . .	239	175	122
„ × Co. 205 . . .	14	12	12
Co. 400 × E. K. 28 . . .	749	718	661
„ × Co. 205 . . .	789	675	597
Co. 403 × E. K. 28 . . .	39	49	55
„ × Co. 205 . . .	72	114	112

It will be seen from the above that the largest number of germinations were obtained when Co. 400 was employed as the ovule parent.

In order to ascertain if there is any correlation between size and germination capacity, measurements of seeds were taken in the varieties, *S. spontaneum*, *Glagah*, *Saretha*, Co. 205, *Vellai* and

Kaludai Boothan. The following table gives their comparative sizes. It is proposed next year to find out the comparative weights also.

TABLE III

Size of seeds in different species of Saccharum

Name of the variety	Length and thickness in microns		Average of
			Seeds
<i>S. spontaneum</i>	1192·95	461·45	100
Glagah	1416·25	555·50	129
Saretha	1301·02	569·25	100
Co. 205	1574·37	523·05	100
Vellai	1787·50	607·95	103
Kaludai Boothan	1561 17	582·17	100

V. DISTRIBUTION FROM THE STATION

(a) AS TRUE SEED

Seeds obtained by crossing P. O. J. 2725 with hardy Coimbatore canes like Co. 243 and Co. 244 were sent to the Director of Plant Breeding, Sydney, Australia, on request. The object of this importation by the recipient country is to secure canes resistant to both frost and diseases. Previous consignments sent to Australia are reported to have yielded promising types.

(b) AS SEEDLINGS

Five thousand seedlings of Co. 213 crossed with Co. 285 and Co. 244 were sent to the Sub-station at Karnal and an equal number of Co. 290 × Co. 281 to the Sugarcane Research Station at Shah-jahanpur. Both the above schemes are financed by the Imperial Council of Agricultural Research and the above seedlings are for exploring the possibilities of selecting and rejecting new seedlings in sub-tropical India even in the nursery stage

(c) AS CANES

Over 200 packets containing sixty varieties, mostly Co.'s, were distributed to over thirty places within Indian limits. The foreign sendings consisting of twenty-one packets were sent to Abyssinia, Leningrad, Washington, Formosa, Sydney and Kenya.

VI. PERFORMANCE OF COIMBATORE CANES

(a) COIMBATORE CANES IN SUB-TROPICAL INDIA

A rather pleasant surprise during the year was the manner in which Co. 223 was working its way in the Kangra District of the Himalayas and at altitudes of over 4,000 feet above sea level. With the cheap water power available in the tract, there would appear to exist distinct possibilities in the future. This discovery is due to the enthusiasm of Khan Bahadur Fateh-ud-din, Officiating Director of Agriculture, Punjab, whose co-operation with the work of Coimbatore has been both long and continuous.

The types mentioned as promising in the previous report are continuing to hold their own, Co. 313 and Co. 331 being rather outstanding. Co. 349 and the Sugarcane \times *Sorghum* hybrid Co. 356 would appear to be among the canes of the future. The area under the improved canes—which is steadily becoming synonymous with Coimbatore canes—touched fifty per cent. during 1932-33. These canes are primarily responsible for increasing the average acre tonnage for the whole of India from eleven to fifteen tons.

(b) COIMBATORE CANES IN TROPICAL INDIA

The new series bred at the thick cane area by Mr. Nand Lal Dutt, M.Sc., has begun to attract attention in most farms both in North and South India. Co. 361 in North-West Frontier Province, Co. 408 at Karnal (Punjab), Co. 413 at Shahjahanpur (United Provinces), Co's. 361 and 407 at Jorhat (Assam) and Co's. 360 and 402 at Padegaon (Bombay Presidency) are at present heading this batch of Coimbatore thick types.

Co. 213, Co. 281 and Co. 290 continue to be popular over certain areas in tropical India, the first named being the most sought for for covering new or indifferent lands. Co. 243 and Co. 313 are the new medium canes of promise in the Anakapalle tract of the Madras Presidency while Co. 290 has found a definite place in parts of the Bombay Presidency under comparatively adverse conditions of soil and irrigation.

(c) COIMBATORE CANES IN FOREIGN COUNTRIES

Co. 281 and Co. 290 followed by Co. 213 are proving useful in foreign countries like Argentina, Louisiana, South Africa and Australia. The former two would appear to have revealed unsuspected resources of both drought and disease resistance, out-rivalling a cane of even such outstanding merit in this direction as Uba.

(d) SUGARCANE-*Sorghum* HYBRIDS

These have been growing in sub-tropical India now for the last two seasons. Though it is perhaps too soon to judge, the indication exists that in sub-tropical India they may not show fitness for milling in six to seven months as at Coimbatore. This might be due either to the employment of the Coimbatore type of *Sorghum* in the first hybridization or to the fact that the crop in sub-tropical India is faced with heavy rains six to seven months from planting. In tonnage and other characters some of these *Sorghum* hybrids (in North India) are hardly distinguishable from the interspecific hybrids now spreading in the tract. One of these—Co. 356—has shown promise of usefulness in more than one North Indian Station. From available information it would appear that certain of them—though not fit for milling in six or seven months as at Coimbatore—might yet be the earliest to mature during the ripening period for canes in the area.

In tropical India the most extensive tests with these hybrids have been in the Madras Presidency where they have been planted and analysed almost month-war. The first year results have been published and it has been found that certain of them attain “a purity of 85 and over in about 200 to 220 days from the time of planting and tend to improve in quality for nearly 100 days afterwards”. “The juices of *Sorghum* hybrids at the point of their maximum efficiency were decidedly richer than those of other Coimbatore canes.” (Viswanath, B., 1934, *Ind. J. Agric. Sci.* 4, 215.)

VII. THE KARNAL SUB-STATION

(a) PROGRAMME OF WORK

The two years' experience, from growing seedlings at Karnal in different ways and planting them in the ground at different times of the year, has given indications about the most effective manner in which to carry on the work programmed for the Sub-station. The best method would appear to consist in effecting the desired crosses at Coimbatore right at the beginning of the arrowing season, sow them in pans at Coimbatore almost immediately after collection, transport the young seedlings to Karnal in a through railway wagon (the seedlings being carefully hardened for the journey) and plant them in the lands at Karnal at the usual planting time for canes in tract. Thus handled, the seedlings show normal growth and allow preliminary selections being made at the end of their first year at Karnal. It is proposed to pursue this method till further experience definitely indicates a better one.

(b) SUGARCANE STUDIES

(i) *Shoot and root studies*.—Results of periodic shoot and root studies were not so effective owing to the absence of a pronounced summer during the year. In a testing station an unfavourable year is of distinct use as it enables the picking out of types that can stand adverse conditions.

(ii) *Juice quality*.—Periodic hand refractometer readings started in August 1933 and continued till February 1934 gave useful information not only on the time of maturity of the different types but also the period during which the different canes maintain their juice quality without serious deterioration; the latter is an important character in cane cultivation, whatever be the nature of the end product, *gur*, *rab* or white sugar.

(c) SELECTION

Of the over 5,000 seedlings grown as seedlings at Karnal, 126 showed sufficient promise for trial in rows. Of the 121 seedlings grown in rows and originally obtained from Coimbatore as cuttings most of them grown at Karnal for two seasons—forty-two were selected for further trial at Karnal and in certain of the Punjab farms. At the end of the year there were 180 new seedlings in row tests besides the 5,000 transported from Coimbatore as seedlings.

(d) DISTRIBUTIONS

Material of the different canes growing at Karnal and consequently, partially acclimatized to sub-tropical conditions, were supplied to the two Sugarcane Research Stations in the Punjab financed by the Imperial Council of Agricultural Research. Material thus supplied exceeded a thousand maunds and included nearly 100 types.

Among material thus distributed mention needs to be made of three canes which were originally obtained from seed collected at Coimbatore and germinated at Karnal. These are early ripeners and should give valuable indications about the future line of work at Karnal. These have been distributed to the Sugarcane Research Station at Shahjahanpur as well, at the desire of the Honourable the Minister for Agriculture in the Punjab.

VIII. PARENTAGE OF COIMBATORE SEEDLINGS

Parentages of seedlings raised to the status of Co.'s during the year are given in Table IV.

TABLE IV

Parentage of Co. canes

Seedling No.	Parentage
Thick Types—	
Co. 421	P. O. J. 2878 × B. 3412.
Co. 422	P. O. J. 2878 × Co. 214.
Co. 423	P. O. J. 2878 × Co. 364.
Co. 424	Kassoer G. C. (likely father Ges. Proanger).
Co. 425	P. O. J. 2727 × P. O. J. 2878.
Co. 426	(Vellai × P. O. J. 1410) × Co. 360.
Co. 427	(Vellai × P. O. J. 1410) × (Kassoer × Badila).
Co. 428	P. O. J. 2725 × Co. 290.
Co. 429	Co. 402 × P. O. J. 2878.
Co. 430	Co. 407 × E. K. 28.
Co. 431	Co. 363 × C. A. C. 87.
Medium Types—	
Co. 500 }	Co. 221 × Co. 229.
Co. 501 }	
Co. 502	Co. 243 × Co. 244.
Co. 503	
Co. 504 }	Co. 317 selfed.
Co. 505 }	
Co. 506 }	Co. 214 selfed.
Co. 507 }	
Co. 508 }	
Co. 509 }	
Co. 510 }	Co. 213 × Co. 244.
Co. 511 }	
Co. 512 }	Co. 213 G. C.
Co. 513 }	
Co. 514 }	P. O. J. 2725 × <i>Sorghum Durra</i> Stapf.
Co. 515 }	
Co. 516 }	

IX. STUDENTS UNDER TRAINING

Two post-graduate students, who joined the station in November 1932, finished their first year at Coimbatore and left for Pusa to do the second year training there. Post-graduate student, Mr. Imdad Ali Khan, joined the Station on 1st December 1933 after completing his first year course at Pusa.

X. MISCELLANEOUS

The study of *S. spontaneums* at Coimbatore carried on under the auspices of the Madras University was completed during the year and the results published in the *Indian Journal of Agricultural Science*.

The sixth meeting of the Sugar Committee appointed by the Imperial Council of Agricultural Research was held at the station 14th to 16th November 1933. This gave a much desired opportunity to the members of the Committee to get first-hand knowledge of the work of the station.

The visitors during the year included Dewan Bahadur Sir T. Vijayaraghavacharya, K.B.E., Chairman, and members of the Sugar Committee, Dr. C. D. Darlington of the John Innes Horticultural Institution, Merton, Dr. P. S. Hudson, Deputy Director, Imperial Bureau of Plant Genetics, Cambridge, Mr. Ebrahim Mahdavy, Officer in charge of the Government Experiment Stations, Iran, and Mr. G. M. Schuitenmaker, Representative of the N. I. V. A. S., Java.

XI. PROGRAMME OF WORK FOR 1934-35

MAJOR

The breeding of medium and thick canes will be carried on with the object of effecting further improvements, covering new tracts or cheapening cost of cultivation.

Attempts will be made to further improve the breeding technique and secure better germination with thick cane seeds.

Studies on the genetics of the sugarcane and of the genus *Saccharum* will be continued and extended.

MINOR

Morphological studies of the thick canes, studies of fertilization and embryogeny and of morphology of chromosomes will be pursued as also of sugarcane roots and of pollen and seed viability.

XII. PUBLICATIONS

- (1) Dutt, N. L. and Krishna-swami, M. K. The Breeding of the Thick Type of Canes for India.
Madras Agric. Jour., Vol. XXVII, No. 3, March 1934.
- (2) Dutt, N. L. and Subba Rao, K. S. A Preliminary Note on the Membraneous Body in the Cytoplasm as characteristic of the Indigenous Indian Canes.
Ind. Jour. Agric. Sci., Vol. IV, Pt. I, February 1934.

- (3) Singh, T. S. N. . . Chromosome Numbers in the Genus *Saccharum* and its Hybrids. *Ind. Jour. Agric. Sci.*, Vol. IV, Pt. II, April 1934.
- (4) Gopala Iyer, K. V. and Venkatraman, T. S. Suggested method of juice analyses for sugarcane plantations devoid of laboratory facilities. (Accepted for publication in the July 1934 issue of *Agric. & Live stock in India.*)
- (5) Panje, Rama Rao . . *Saccharum spontaneum* L. A comparative study of the forms grown at the Imperial Sugarcane Breeding Station, Coimbatore. *Ind. Jour. Agric. Sci.*, Vol III, Pt. VI, December 1933.
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REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST

(J. N. MUKERJI, B.A., B.Sc.)

I. CHARGE

Mr. J. N. Mukerji, Assistant Agricultural Chemist, held charge of the section throughout the year, in addition to his own duties.

II. EDUCATION

Of the two post-graduate students, Messrs. Mohini Nath Phukan, M.Sc., and Sailesh Chandra Sen, M.Sc., who were admitted in November 1932, the former is still continuing his studies. The latter left the course on the 22nd December 1933 to join the appointment of assistant chemist at the Sugarcane Research Station, Museri, under the Bihar Agricultural Department.

Messrs. K. Swaminathan, M.Sc., and Narendra Kumar Das, M.Sc., who were admitted to the post-graduate course on the 8th November 1933, are continuing their studies.

III. METEOROLOGY AND DRAIN-GAUGES

The usual meteorological records (except that of anemometer from 16th January to date) and records of drainage from four drain-gauges were maintained. Owing to the heavy damage done to the Institute building by the great earthquake of the 15th January, the readings of the anemometer, combined Anemo-Biograph and Wind Direction Recorder, and the Natural Syphoning Recording Rain-gauges which were set up on the roof of the Institute building, had to be discontinued.

In connection with drain-gauges, sann-hemp and wheat crops from the gauges and 175 samples of drainage waters were examined.

IV. GENERAL ANALYTICAL WORK AND ASSISTANCE GIVEN TO OTHER SECTIONS

The following samples were analysed and reported upon :—

Soil	41
Manures	21
Feeding stuffs	17
Oil seeds	12
Sugarcane	467
Water	5
Drugs	7
Miscellaneous	2

Besides those made in connection with the work of this section, the analyses made for other sections of the Institute and for departments and persons outside Pusa are indicated briefly as follows:— For the Agricultural Section eight samples of manures, 308 of Sugarcane in connection with the farm's variety test, manurial experiments, trashing experiments, etc., seven of soil, and seven of feeding stuffs were analysed. For the Botanical Section, 12 samples of linseed, five of manures, six of barley flour, seven of Ganja (Indian Hemp) and one of tomato fruit, were analysed. The barley flour samples were examined for their starch, proteid, fat, ash and fibre contents in order to see how they compare with the barley flour imported from foreign countries. Of the seven Ganja samples examined, Flat Ganja Type 1 was found to be the best, both in respect of specific rotation and resin content. Besides these a report on the chemical composition of 34 samples of soil and subsoil and on the mechanical analysis of 90 samples of soil and subsoil from Karnal Sub-Station under the Imperial Economic Botanist, was issued. A report on the chemical analysis of 10 samples of soil and subsoil, and on the mechanical analysis of 24 samples of soil and subsoil from Karnal Sugarcane Area under the Sugarcane Expert, Coimbatore, was also made.

For the Mycological Section 91 samples of sugarcane from mosaic tonnage plots, and one of nutrient solution were examined. For the Bacteriological Section, one sample of kudzu vine, and three of silage prepared from kudzu vines were analysed, and for the Entomological Section 68 samples of sugarcane were analysed in connection with the damage done by top shoot borer, stem borer, root borer and termites, individually and collectively.

Four samples of soil and four of manures were received from the Assistant Director of Agriculture, Bannu, North-West Frontier Province. One of these samples of soil contained a high percentage of water soluble salts mostly in the form of sulphates. All the four samples of soil were very deficient in available phosphoric acid content. A sample of Bara river silt was received from the Agricultural Officer, N. W. F. Province, Peshawar, for examination of its manurial value. This silt compared to Gandak river silt was far superior both in respect of nitrogen and phosphoric acid contents and had an appreciable manurial value. 22 samples of soil received from the Sugarcane Specialist, Sugarcane Research Station, Museri, were examined for their hydrogen ion concentration. A sample supposed to be of calcium sulphate, received from the Director of Agriculture, North-West Frontier Province, was found to contain about 70 per cent. chalk and no calcium sulphate.

Analysis of five samples of soil and five of spring water from Kalat was carried out for the Irrigation Officer in Baluchistan, and two of manures carried out for the Military Grass Farm, Lucknow.

V. RESEARCH

1. CROPS

Effect of manures on the yield and quality of sugarcane.—The manurial experiment with sugarcane (Co. 213) was carried out in 1933-34 with a view to ascertain if the quality and yield of the crop could be improved when sulphate of potash and superphosphate of lime are applied either separately or together, in addition to mustard cake. The experiment was a repetition of the one carried out in 1932-33, when owing to the vigorous growth of the crop attended with rainfall and high wind, a considerable part of canes had lodged and the germination in few of the plots were affected owing to the existence of big trees in the vicinity.

The conditions prevailing during the year under observation were fair and the experiment was conducted with bigger plots in 4 replications for each treatment in Latin squares. The following treatments for the purpose were adopted: (1) Mustard cake at 100 lbs. N. per acre, (2) Mustard cake at 100 lbs. N. with sulphate of potash at 50 lbs. K_2O per acre, (3) Mustard cake at 100 lbs. N. with superphosphate of lime at 100 lbs. P_2O_5 per acre and (4) Mustard cake at 100 lbs. N. *plus* superphosphate of lime at 100 lbs. P_2O_5 , *plus* sulphate of potash at 50 lbs. K_2O per acre. The size of each plot was 46 ft. by 33 ft. A border crop 3 ft. all round was excluded at harvest and the inner crop covering an area of $\frac{1}{10}$ th acre for each plot was taken into consideration for the purpose of the experiment. The manures were applied in two doses, $\frac{1}{3}$ rd at the sowing time and $\frac{2}{3}$ rd three months after sowing. The germination was uniform and the crop grew well and at the harvest gave an yield varying from 1,078 to 1,200 maunds per acre for different treatments.

The application of superphosphate of lime with mustard cake had the effect of increasing the yield over mustard cake alone by about 120 maunds per acre, and that of superphosphate with sulphate of potash and mustard cake by about 123 maunds per acre, over mustard cake alone. Sulphate of potash with mustard cake had the effect of increasing the yield over mustard cake alone by only 24.4 maunds per acre. The results were found to be statistically significant with the former two, while with the latter, it was not significant. With regard to the available sugar, superphosphate with mustard cake, and superphosphate *plus* sulphate of potash *plus* mustard cake gave an increase over mustard cake alone by 14.4 and 12.9 maunds per acre respectively. Sulphate of potash with mustard cake had the effect of increasing the quantity of available sugar by only 3.9 maunds per acre over mustard cake alone. As with the total yield, so with the available sugar also, the former two treatments gave significant results, while the latter did not.

Considering the result from the economic point of view superphosphate with mustard cake gave the best result, both in respect

of total yield and of available sugar. As regards the quality of juice it was hardly affected by any of the above manurial treatments.

Experiment on the quick availability of Natural Indigo for dyeing purpose.—Natural Indigo from Bihar is prepared into dry cakes for the market and contains about 60 to 65 per cent. indigotin. It cannot be used for dyeing purpose readily. The cake has to be ground into a very fine powder, converted into a paste of uniform consistency and reduced by bacterial action or by reducing agents to Indigo white (which is soluble in water), before it can be used for dyeing purpose. Finally the cloth dyed in the indigo white on exposure to atmosphere, is oxidised by the oxygen of the atmosphere and the indigo white changes to indigo blue. Indigo, whether natural or synthetic, is insoluble in water and it has to be reduced to indigo white, before it can be used for dyeing purpose. For the reduction of indigo to indigo white readily, one of the necessary conditions is to bring the indigo into the form of a paste of uniform consistency with the particles remaining in suspension in as fine a state as possible, or in other words it should be brought into a colloidal state.

With a view to bring the paste into a colloidal state and to maintain it in such state without fermentation when kept in sealed tins, the paste, as reported last year, was treated with sodium carbonate in proportion of 1, 1.5 and 4.5 per cent. on the weight of paste and subsequently heated in water bath for 8 hours at 80°C. 1 and 1.5 per cent. sodium carbonate proved totally ineffective, inasmuch as the paste fermented very badly within 4 days. Treatment with 4.5 per cent. sodium carbonate, however, stopped fermentation to a good extent, without in any way diminishing the indigotin content or destroying the strength of colour. Treatment with sodium carbonate in proportion of 1.5 per cent. of the weight of paste and subsequent heating at 120°C. under 1 atmosphere pressure for 40 minutes in autoclave, as reported last year, proved successful and completely stopped fermentation. The same result was obtained by treatment with 1.5 per cent. sodium carbonate, and subsequent heating in air oven at a temperature of 105°C. for 12 to 15 hours.

Trials with such antiseptics as borax and sodium salicylate in proportion of 1.5 to 2 per cent. of the fresh indigo paste as available immediately after *Mahai*, were given. Sodium carbonate as already shown, does not interfere with the chemical determination of indigotin, so sodium salicylate too; but borax on the other hand interferes and gives a misleading result. The use of borax as an antiseptic, therefore had to be abandoned. Treatment with sodium salicylate at 1 and 2 per cent. on the weight of paste and subsequent heating in air oven at 105°C. for 12 hours proved as effective as with sodium carbonate. A trial was given with 5 per cent. sodium salicylate, which was thoroughly mixed with the paste and kept in sealed tins without heating. This treatment successfully prevented

the fermentation and decomposition of the indigotin. As a preservative sodium salicylate was found better than sodium carbonate. The contents of the sealed tins treated with sodium salicylate, when opened and examined after four months were found to be unchanged and free from fermentation. It is now intended to give dyeing trials with the indigo pastes preserved with sodium carbonate and sodium salicylate and find out how they compare with ordinary natural indigo cake.

2. SOILS AND FERTILIZERS

The study of lime requirement of an acid soil.—Mr. S. Das continued the study on the lime requirement of soils during the year. *Ragi* (*Eleusine coracana*) was grown in the several groups of pots of Jorhat acid soil under varying doses of lime based on its lime requirement. When seedlings were about one month old, a photograph was taken of them, which showed a progressive growth according to various treatments. When however the crop was harvested, the grain did not show any marked difference in mean yields.

A crop of oats was next raised in these pots last winter with the renewal of a basal dressing of nitrogen, phosphate and potash. The plants in pots which had the heaviest application of lime rendering the acid soil distinctly alkaline with a pH of 7.6 flowered latest of all and behaved similarly to the plants in pots containing the original soil with no addition of lime and having a pH of 4.7.

The crop yields in pots where lime was added in proportion of 1/3, 2/3, and equivalent of lime necessary for complete satisfaction of the lime requirement of the Jorhat acid soil were distinctly better than those secured with the control where no lime was applied. In pots where 2, 3 and 4 times the lime necessary to satisfy the lime requirement were added and thus alkalinity was developed in the several soil mixtures, the crop yields were very poor, even lower than the control. The experiments are being continued with *ragi* as the *kharif* (monsoon) crop in these pots after a renewal of the basal dressing of nitrogen, potassium and phosphorus.

The Limiting factor of phosphate requirements of Calcareous soils.—Calcareous soils belonging to the trans-Gangetic alluvium and containing from 30 to 40 per cent. of chalk respond to the application of phosphatic fertilizers. It is not however exactly known what amount of phosphate gives the best cropping results. Of course, the amount required will depend, other things being equal, upon the kind of crops grown. In order, however, to arrive at a working figure for ordinary agricultural practice, two series of pot experiments with Pusa soil containing about 35 per cent. of chalk were carried out with *ragi* (*Eleusine coracana*) under various doses of calcium phosphate. Basal dressing of potash and nitrogen were given to all the pots at the rate of 80 and 100 lbs. per acre respectively. Potash was applied as potassium sulphate, and nitrogen as

ammonium sulphate and green manure separately in the two series. The crop yield showed that the application of 100 lbs. of P_2O_5 per acre or 0.005 per cent. P_2O_5 to Pusa soil proved better than lesser applications of phosphates. The results were found to be statistically significant when examined by the Fisher's method of analysis of variance. The application of higher doses of P_2O_5 even upto 1,600 lbs. per acre did not produce significantly better yields.

Another fact emerging from these experiments is that the application of green manure did not prove better than ammonium sulphate when applied to supply nitrogen, both of them rather yielded practically identical results.

The experiment was repeated last winter with mustard applying P_2O_5 as tri-calcium phosphate in pots at the rate of 60, 70, 80, 90 and 100 lbs. per acre with basal dressing of nitrogen as ammonium sulphate only and potash as potassium sulphate. Although different doses of phosphate produced better yield than the control, and the results were found to be statistically significant, there were not however significant differences between mean yields of different treatments owing perhaps to the crop being damaged by *aphis* and other insects at the maturing stage. The experiment is being continued with *ragi* as the *khariif* crop to arrive at the actual limit of phosphate requirement of these calcareous soils. A series of field experiments with modern technique has also been started in order to work out the phosphate requirement. Superphosphate has been applied to supply P_2O_5 at the rate of 50, 70, 80, 90 and 100 lbs. per acre. A basal dressing of potash and nitrogen has been given to all the plots at 80 and 100 lbs. per acre as sulphates of potassium and ammonium respectively. There is a group of control plots for comparison. *Ragi* seedlings have been transplanted for *khariif* crop to be followed by a *rabi* (winter) crop in order to study the residual effect of the manures.

Availability of superphosphate in Calcareous soils with placement of depth.—Several workers have shown that phosphorus remains largely where it is placed in the soil, and hence the failure to obtain a profitable response to superphosphate in calcareous soils may be due to the improper placement of the fertilizer. Should therefore superphosphate be applied at different depths in such soils, a variation in response is expected, depending on whether a crop is shallow-rooted or a deep-rooted one, and in this way the proper depth of application of superphosphate can be discovered for particular crops. With this object in view superphosphate was applied at 100 lbs. P_2O_5 per acre to several groups of pots containing a calcareous soil (Pusa) at different depths, *viz.*, at surface, and at 4, 8, 12 and 16 inches below the surface, and also mixed throughout the whole mass of soil. There was a group of control pots for comparison where no phosphate was applied. Basal dressings of potash as potassium sulphate and nitrogen as ammonium sulphate were given at 80 and 100 lbs. per acre respectively. Mustard was grown.

Cropping results showed that the application of superphosphate to soil at 4 inches below the surface gave the best yield, and then the yields gradually fell with the lowering of the depths of application of superphosphate. The yields from application of superphosphate at surface and of superphosphate mixed throughout the whole mass of soil in the pots were almost identical and the least, when compared with the yields obtained from other applications, all of which however produced higher yields than the control. It is therefore evident that the application of super at 4 inches below the surface gives the best results in calcareous soils with a crop like mustard. After the harvest 4 inches soil borings at different groups of pots were taken and the examination of their total phosphate contents showed that the phosphate did not reach downwards from the depths where it was applied. This is in accordance with the observation of other workers. A fresh series of pot experiments has been started under almost similar lines with *Eleusine coracana* as the *kharif* crop.

Relative availability of natural and artificial phosphate in calcareous soils.—With a view to study the relative availability of some natural and artificial phosphates in calcareous soils, a series of pot experiments were started in the winter of 1933. Natural phosphates like bonemeal, apatite and Trichi-nodules which are available in quantity in this country, and also artificial phosphate like superphosphate, di- and tri-calcium phosphates, and phosphates of ammonium, sodium, potassium, magnesium, iron, and aluminium were used to supply phosphates at the rate of 100 lbs. of P_2O_5 per acre to pots having a calcareous Pusa soil with about 35 per cent. of chalk. A basal dressing of potash and nitrogen at 80 and 100 lbs. per acre was given to all the pots as sulphates of potassium and ammonium respectively. There was a group of control pots for comparison which contained no phosphates. Mustard was grown as the *rabi* (winter) crop.

The results showed that the pots treated with phosphates always produced a higher crop return than the control, and the increased yield varied between 19 and 127 per cent. over the control according as the different phosphatic manures were used. Natural phosphate as well as aluminium phosphate gave rather lesser yield, compared to the rest of the phosphates. The results when examined by the Fisher's method of analysis of variance, were found to be statistically significant in all cases except with apatite and aluminium phosphate, which, however, produced higher crop yields than the control. Trichi-nodules gave statistically significant results for 5 per cent. and the rest for even 1 per cent. level of significance.

Eleusine coracana has been grown as the next *kharif* crop to study the residual effect of these phosphatic manures, if any. In this connection, a scheme of field experiments with modern technique has been drawn, to be carried out during the coming winter in order

to study the relative availability of some natural and artificial phosphatic manures in calcareous soils.

The manurial value of different phosphates in calcareous soils.—In connection with the investigation on this subject carried out by Mr. Das in this laboratory some time ago, further experiments on the reaction of calcium carbonate with different sodium phosphates used were conducted. It was found that there was no action between calcium and sodium meta and pyro-phosphate solutions even after prolonged shaking. Such a reaction is improbable, as higher phosphates of calcium are not formed at ordinary laboratory temperature, but require a pretty high heat for their preparation. Consequently the absence of any reaction ensures a more uniform distribution of these phosphates and their consequent better manurial value in calcareous soils. The conclusion is therefore forced that the higher soluble phosphates of the type containing either P O_3 or P_2O_7 ions which have no reaction with calcium carbonate give the best cultural results in calcareous soils by effectively supplying the phosphatic nutrition of plants, notwithstanding the presence of an inordinately large amount of chalk in them.

A reaction, however, takes place between calcium carbonate and disodium hydrogen phosphate solution. The relationship between the amount of P_2O_5 precipitated by calcium carbonate and the time of reaction is a simple semi-logarithmic one, and can be expressed by the general equation

$$\log t = ay - k$$

where y is the amount of P_2O_5 retained in time t and a and k are constants. Under the experimental conditions, the reaction is strongly retarded and can only reach completion at the end of a considerable period of time, which when calculated from the experimental data is found to be over six months. These experiments were carried out by shaking the reacting substances in a comparatively large volume of water, and do not approximate to soil conditions, where these substances are static and where the volume and the rate of movement of water are comparatively small. Therefore, *in situ* in soil the rate of such action will be far slower. Hence soluble phosphates of the above type reacting slowly or not at all with calcium carbonate as in the case of sodium meta- and pyrophosphates, will have enough time during the growing season to get themselves easily distributed more uniformly into deeper layers, resulting in a wider and deeper root action and better cropping in calcareous soils.

The effect of Potash on yield in calcareous soils.—The apparent ineffectiveness or even depressing effect of potassic fertilizers, used alone on yield has been observed in several field experiments conducted at Pusa. In order to arrive at a definite conclusion on this point and with a view to find out if the ineffectiveness or depression indicated in the field trials at Pusa is due directly to potash or to

some other indirect cause, properly conducted experiments with wheat in pot and field were started during the last cold weather.

The pot experiment was designed to compare the independent effect, in calcareous soils of potash as (a) potassium sulphate and (b) potassium carbonate with that of nitrogen as ammonium sulphate, and P_2O_5 as mono-calcium phosphate, without the basal dressings in any of the sets. Besides the control, one of the sets in this experiment included calcium sulphate, the individual effect of which in highly calcareous soils was also studied along with others.

The results of pot experiment, in case of ammonium sulphate and mono-calcium phosphate, on being statistically treated by the Fisher's method of analysis of variance, were found to be significant. In case of other applications, the results were not significant. The highest mean yield was from mono-calcium phosphate which gave an increase of 130 per cent. over the control and the least was from potassium sulphate which decreased the mean yield by about 5 per cent.

The field experiment was laid over 25 small plots of equal area where the individual effect of potash as (a) potassium sulphate, (b) potassium carbonate and (c) potassium chloride was tested. As in pots, so here too the effect of calcium sulphate was also studied. None of these applications of potassium salts, when treated statistically, gave significant results.

Based on the results of the pot experiment, a series of field experiment with modern technique has been started in the Pusa Farm in order to compare the individual effect of potash with the individual effect of nitrogen and of phosphate. Superphosphate has been applied to supply P_2O_5 at the rate of 80 lbs. per acre and ammonium sulphate applied to supply nitrogen at the rate of 80 lbs. per acre. Potash as (1) sulphate of potash, and (2) potassium carbonate, each at 40 lbs. per acre, and Gypsum (Calcium sulphate) at 60 lbs. per acre have been applied. There is a group of control plots for comparison. *Ragi* (*Fleusine coracana*) seedlings have been transplanted for the *kharif* crop to be followed by a *rabi* crop next winter in order to study the residual effect of these manures.

The limiting factor of potash requirements of calcareous soils.—In order to find out the limiting factor of potash requirements in calcareous soils, two series of pot experiments with a calcareous Pusa soil have been started. In the first series sulphates of potash and ammonium have been altogether eliminated as well as calcium sulphate which is contained, to a large extent, in the commercial superphosphate. Commercial ammophos has been used in all the pots to supply both nitrogen and phosphate as a basic dressing at 80 and 100 lbs. per acre respectively instead of ammonium sulphate and superphosphate. Potassium chloride has been used in the place of potassium sulphate to supply potash to groups of pots in different doses varying from 20 to 100 lbs. per acre in order to arrive at an

actual limit of potash requirement of these calcareous soils. *Ragi* has been grown as the *kharif* crop, to be followed by barley or any other suitable crop in the *rabi* season in order to study the residual effect.

In the second series, as in the case of previous experiment, sulphates of potash and ammonium, and commercial superphosphate have been applied in the same doses as in the first series. Except the variation of manurial treatment, the procedure followed in both the series is identical.

The fresh weight of twelve *ragi* seedlings of a fortnight's growth from each group of four pots under various doses of potash manures were taken for comparison. In both the series the seedlings exhibited a significant response to the various doses of potash in addition to the basal dressing of nitrogen and phosphate. This effect was, however, more pronounced in series I than in series II. It may perhaps be due to the adverse action of sulphates of potassium and ammonium on calcium carbonate present in calcareous soils and to the deleterious effect of calcium sulphate already contained in the superphosphate used in series II. The subject is under study.

Efficiency of wild apricot seed cake as a nitrogenous manure.—Earlier work in this laboratory reported last year has shown that about 60 per cent. of nitrogen present in the cake may be transformed into available forms in three dissimilar types of soil, viz., Pusa, Kalianpur and Solon soils in about two months' incubation. Pot experiments have since been conducted with these soils with the following conclusions :—

- (1) The application of 80 lbs. of nitrogen per acre as cake produced the maximum yield of wheat in Pusa and Solon soils and 100 lbs. in Kalianpur soil. The results obtained were statistically significant, when examined by the Fisher's method of analysis of variance.
- (2) According to the increasing doses of the cake varying from 20 to 100 lbs. of nitrogen per acre the crop yield increased from 85 to 155 per cent. over the control in Pusa soil, 94 to 300 per cent. in Kalianpur soil and 19 to 94 per cent. in Solon soil.
- (3) The residual effect of the cake was tested in Pusa soil alone, where 100 lbs. of nitrogen only gave significantly higher yields of *ragi* (*Eleusine coracana*) over the control, the rest of the applications giving somewhat higher yields than the control, though not statistically significant.
- (4) From the curves of crop yield with various doses of the cake a similarity of manurial effect is apparent in Pusa and Solon soils, whereas in the case of Kalianpur soil this effect though similar for two doses only, viz., 40 and 80 lbs. of nitrogen per acre, is not so for the rest. This

effect is, however, most pronounced in Kalianpur soil demonstrated by a remarkably high crop yield.

- (5) The cake being effective with an important crop like wheat in three different types of soil, it will undoubtedly prove as an efficient nitrogenous manure for soils which are particularly deficient in this constituent, and specially so on agricultural lands in the neighbourhood of Solon near Simla Hills where it is available in plenty, but at present wasted as a fuel only.

Study of soils of tobacco tracts in India.—During the year under report, tobacco soils from Saharanpur in the United Provinces, Guntur in Madras and Dacca in East Bengal, were obtained. At Saharanpur the tobacco crop is grown during monsoon between June and September, harvested towards the end of September and cured during October. Saharanpur and most of the north-western districts of the United Provinces are visited by frost during winter and if tobacco is grown in these parts during winter season, as is the case in other tobacco growing districts of India, the crop is very likely to be spoilt by frost. Saharanpur soil being mostly sandy, it is possible to grow tobacco here during monsoon without much trouble.

The chemical examination of 8 samples of tobacco soils that were obtained from the Kaira district in Northern Gujarat last year have been completed. Almost all the soils that were obtained from this district were found to be rich in their nitrogen, phosphate and potash contents, the available phosphate in most cases being unusually high.

Owing to the heavy damage done to the Institute building by the great earthquake of the 15th January, resulting in the dislocation of work, and the removal of the laboratory from the Institute building to a temporary building which had to be fitted up with gas and water, the progress of laboratory work was considerably hindered, and the examination of the soils that were brought from Rangpur and other places during last year could not be completed.

3. ANIMAL NUTRITION

Experiments on the feeding value of various fodders.—In the method of valuation of fodders by the starch equivalent system, only that part of the food which the animal assimilates, and which is considered as of direct value, is taken into account. Digestibility experiments have been carried out in Europe and America, but very little has been done in India. In the absence of any such figures as "digestibility coefficients" of Indian feeding stuffs and fodders tried with Indian cattle, Dr. Kellner's figures are the only guide, at present for working out the starch equivalent and arrive at the feeding value of different feeding stuffs and fodders.

The live weight of an average European cow or bullock is much higher than that of an average Indian cow or bullock and the power of assimilation of an average European cow or bullock cannot be similar to that of an average Indian cow or bullock ; consequently Dr. Kellner's figures are not applicable in case of Indian feeding stuffs and fodders tried with Indian cattle.

Digestion experiments with reference to certain fodders on six bullocks have therefore been started in collaboration with the Physiological Chemist and the Imperial Agriculturist. In this connection two experiments each lasting for ten days have been completed. In the first experiment, three animals were fed on oatstraw and three on maize silage in addition to rape cake which was common to all. In the second experiment oatstraw was substituted by oats hay and maize silage by Berseem silage mixed with oat straw. Preliminary feeding is going on for the third experiment with Berseem hay and maize kutty as the roughages.

VI. RESEARCH PROGRAMME FOR 1934-35

1. *Study of the Soils of tobacco tracts in India.*—Physical and chemical examination of typical tobacco soils already obtained from Rangpur (Bengal), Dacca (East Bengal), and Guntur (Madras) will be continued. Typical tobacco soils from the districts of Trichinopoly and Madura in Madras and from Cooch Bihar and Jalpaiguri in Bengal will be obtained for the purpose of this study.

2. *Effect of potash on the yield of crops.*—The yield of *kharif* and *rabi* crops from the 25 small experimental plots in replications of five for each treatment will be recorded for the year 1934-35. Pot culture experiment to compare the effect of potash with that of nitrogen and of phosphate will be repeated. A series of field experiments on the same line as that of pot culture, has been started in the Punjab Experimental Area of the Pusa Farm. *Eleusine coracana* seedlings have been transplanted for a *kharif* crop to be followed by a *rabi* crop. The results when ready will be submitted to the Fisher's method of analysis of variance in order to find out the significance.

3. *Effect of manures on sugarcane.*—The effect of oil cake (mustard cake) alone, and in combination with either superphosphate of lime or sulphate of potash or both, will be further studied on sugarcane grown in randomised plots in replications of six for each treatment. Besides these, effect of (1) molasses with sulphate of ammonia and (2) molasses with sulphate of ammonia and superphosphate of lime will be studied in randomised plots in replications of six for each treatment. There will be control plots as well.

4. *Lime requirement of acid soils.*—The cropping power of an acid soil by means of pot experiments after the addition of incremental amounts of lime in proportion to its lime requirement is to be further examined. *Eleusine coracana* has been grown as the *kharif* crop in an acid Jorhat soil for the purpose. There is also a corresponding series of uncropped pots side by side to supply sample of soil for periodical examination in the laboratory.

5. *Limiting factor of phosphate requirements of calcareous soils.*—(a) Pot experiments are being continued on the addition of calcium phosphate at the rate of 50, 70, 80, 90 and 100 lbs. of P_2O_5 per acre to arrive at an actual limit of phosphate requirement of calcareous soils. *Eleusine coracana* has been grown as the *kharif* crop for the purpose.

(b) A similar series of field experiments with modern technique has been started in the Punjab Experimental Area of the Pusa Farm. *Eleusine coracana* seedlings have been transplanted for a *kharif* crop to be followed by a *rabi* crop in order to study the residual effect of the manures, if any.

6. *Availability of superphosphate in calcareous soils with depth of placement.*—The failure to obtain a profitable response to superphosphate in calcareous soils may be due to the improper placement of the fertilizer. In order to test this, pot experiments with a calcareous Pusa soil are being continued, in which superphosphate has been placed at surface and at 3", 6", 9" and 12" below the surface, and also mixed throughout the mass of the soil, each to a group of four pots. There is a group of control pots for comparison. *Eleusine coracana* has been grown as the *kharif* crop.

7. *Relative availability of natural and artificial phosphates in calcareous soils.*—(a) Pot experiments with a calcareous Pusa soil where different phosphatic fertilizers were applied and a crop of mustard raised last winter, are being continued this summer in order to study the residual effect of these manures with *Eleusine coracana*.

(b) There is also a scheme of field experiments with modern technique to be conducted in the Punjab Experimental Area of the Pusa Farm next winter in order to study the relative availability of some natural and artificial phosphatic fertilizers in calcareous soils.

8. *The limiting factor of potash requirements of calcareous soils.*—Pot experiments have been started with a calcareous Pusa soil to which potash has been supplied in different doses varying from 20 to 100 lbs. per acre in the form of chloride and sulphate of potassium separately in series I and II. In one series nitrogen and phosphate have been supplied as ammophos, and in the other as sulphate of ammonia and superphosphate as a basic dressing to all the pots. There are control pots for comparison. *Eleusine coracana* has been grown as the *kharif* crop, which will be followed by a *rabi* crop in order to study the residual effect of potash manures, if any.

9. *The effect of manures on the vertical distribution of P, CaCO₃, and replaceable bases of calcareous soils.*—3" soil borings up to 5' depth have been taken from the nine Permanent Experimental Plots of the chemical section and a fallow plot of the Pot culture House Area. These samples are to be examined for P, CaCO₃, N, C, K₂O, clay and certain physical properties and replaceable bases in order to find out the effect of manures on the distribution of P, CaCO₃ and replaceable bases in calcareous soils and their relation to other relevant factors.

10. *Solubilization of apatite by chemical methods.*—Treatment with different chemicals will be attempted to render apatite available to plants.

11. *Colorimetric determination of phosphorus in soils.*—Trough and Meyer's modification of the original colorimetric method will be tested to compare a few important methods of determining readily available phosphorus of type soils in India with known manurial and cultural history and to arrive at a suitable standard of their phosphate requirements.

12. *Critical Examination of Pemberton Kilgore method of estimating phosphoric acid.*—It is intended to make a critical study of the method.

13. *Experiments on the feeding value of various fodders.*—Digestion experiment on the following fodders, viz.

1. Berseem hay (2nd cutting)+Green maize *kuttee*
2. Berseem hay (3rd cutting)+*meth* and *juar*
3. Berseem hay (4th cutting)+*sanwi* grass

will be carried out.

VII. PUBLICATION

Das, S. The Manurial value of different Phosphates in calcareous soils (submitted for publication).



REPORT OF THE PHYSIOLOGICAL CHEMIST.

[F. J. WARTH, D.Sc. (BIR.), B.Sc. (LOND.), I. A. S.]

I. CHARGE

I was in charge of the section for the year with the exception of the period from 1st July 1933 to 22nd November 1933, when Mr. A. Viswanatha Iyer, Assistant Physiological Chemist, was in charge.

II. LABORATORY WORK

The following is a list of analyses completed during the year :—

Complete analyses—

1. Fodders	. . . . .	40
2. Faeces	. . . . .	75
	— — —	115
Dry matter in faeces, urine, fodders, etc.	. . . . .	2,106
Single nitrogen determination in fresh faeces, fodders, urine, etc.	. . . . .	292
Mineral analyses of urine, fodders, faeces, etc.	. . . . .	232
Determination of protein, phosphoric acid and calcium in blood of cattle	. . . . .	290
Miscellaneous	. . . . .	401
	— — —	
	Total .	3,346

III. RESEARCH WORK OF THE SECTION

1. EXPERIMENTS ON MILK PRODUCTION

(a) *High and low protein feeding.*—Further information is available from the experiment commenced last year. The accompanying table shows the daily average food consumption and the milk yield per head for each group. Figures are given for the first four weeks and for the first twenty weeks of lactation respectively.

Food consumption and Milk yield by Cows on High and low protein ration

	Average for first four weeks lactation		Average for first twenty weeks lactation	
	A	B	A	B
	Low protein	High protein	Low protein	High protein
	lbs.	lbs.	lbs.	lbs.
Fodder dry matter . . .	11·97	10·47	11·61	10·44
Concentrate matter . . .	9·66	11·21	8·08	9·18
Total matter . . .	21·63	21·68	19·69	19·62
Do. digestible protein . .	2·36	3·58	2·01	2·36
Do. starch equivalent . .	11·27	12·35	10·16	10·98
Milk Yield lbs.	18·40	21·40	14·70	17·20

The points to be noted are :—

1. Total food consumption for the two groups is identical. To compensate for the extra concentrate given to group B the cows of group A eat more fodder.

2. Although the total food is identical the food of B group contains a higher proportion of concentrate and hence possesses a higher starch equivalent value. Corresponding to the higher starch equivalent value of the ration there is a higher milk yield. This matter of milk yield requires corroboration by repeated tests, which are about to be commenced.

3. The protein content of ration B is very high. The tests must be continued to see how the cows tolerate the high protein level.

In a general way the data confirm the starch equivalent values assigned by the Nutrition Section to our foodstuffs.

(b) *Experiment to determine the value of Molasses for milk production*.—The two groups of cows selected for this experiment, though well matched in other respects, differed initially in milk yield, and hence it is difficult to judge the effect of subsequent feeding.

The accompanying tabular statement shows that the rate of decline in milk yield of the two groups was identical, which indicates that the two rations were equivalent in value and effect.

Table showing the average daily food consumption dry matter milk yield and live weight.

No. of week	Non-molasses group			Molasses group		
	Total dry matter consumption in lbs. per day	Average daily milk yield in lbs.	Average daily live-weight	Total dry matter consumption in lbs. per day	Average daily milk yield in lbs.	Average daily live weight
1	22·203	17·6	745	20·460	16·4	739
2	22·430	17·2	748	20·710	15·9	740
3	21·720	16·9	749	20·570	15·8	741
4	21·950	16·6	752	20·560	15·6	742
5	22·190	16·4	755	10·170	15·9	740
6	21·097	15·5	759	20·630	15·0	744
7	18·930	15·3	754	17·780	15·0	747
8	20·213	15·1	755	One animal sick in molasses group.		
9	20·360	14·9	758	19·230	14·1	744

The consistent and curious difference in food consumption between the two groups is noteworthy and requires consideration. Part of the difference is accounted for by the fact that molasses were used weight for weight to replace some of the concentrate. As the molasses contain much water, the molasses group received somewhat less concentrate dry matter (7·8 lbs. as compared with 8·4). In addition to this shortage in the provision, the molasses group consumed less fodder by choice (12·1 lbs. as compared with 12·8).

Generally a short provision of one item of the ration leads to increased consumption of the other items. In the above molasses test there has been no such balancing effect.

2. EXPERIMENTS WITH WORKING BULLOCKS

Preliminary experiments with working bullocks have been carried out during the present season.

Three pairs of large cross bred bullocks were employed on ploughing work. The work was measured by determinations of the draft, the speed of movement and the total distance traversed daily. The food consumption was determined accurately and the live weight noted daily.

The test was divided into two periods the first period being on light work with a small plough and the second period on heavy work with a heavy plough.

Unfortunately owing to a change of weather, the work decreased very considerably in successive weeks. The following table shows

the average live weight and average daily work performed by one bullock :—

Week ending	Average live weight lbs.	Average work Million foot lbs.
12th May 1934	1139	1.72
17th May 1934	1136	1.87 light work.
26th May 1934	1142	1.80
2nd June 1934	1130	7.33
9th June 1934	1122	7.14
16th June 1934	1117	6.76
23rd June 1934	1116	6.51 heavy work.
30th June 1934	1117	6.94
7th July 1934	1115	5.96
14th July 1934	1120	6.38

It is generally understood that the draft should not exceed one-tenth of the live weight. In these tests the draft has been one-fifth to one-sixth of the live weight and yet the animals have not shown any sign of suffering.

The live weight figures show that there was a smart and appreciable fall when the heavy work commenced, but the fall became less and eventually equilibrium of live weight was established. The food consumption data would seem to indicate that the animals were not consuming enough food for the work done. Viewed from these various points the results are remarkable.

There is one feature which remains to be noticed, namely the gait of the animals. These bullocks move very slowly (average about 98 ft. per minute when ploughing). The work is performed slowly and the horse power developed is relatively low.

These tests seem to indicate that the gain of efficiency due to slowness of performance is greater than anticipated.

For comparison a few tests have been carried out with one pair of Mysore bullocks. It was observed that these animals have a naturally fast gait (163 ft. per minute when ploughing) with the consequence that the work they did was performed rapidly. It is noteworthy that with these animals the loss of condition became serious although their food provided more nearly the theoretically necessary starch equivalent than was the case with the large slow moving animals. Here it appears that rapidity of performance has materially reduced the efficiency of utilization of food energy.

The data are interesting from various points of view and will be submitted for publication at an early date.

3. DIGESTIBILITY TRIALS WITH COARSE FODDERS

This work has been continued along the lines followed during the past two years, the main object being to determine the effect of advancing maturity upon composition and digestibility.

Some typical results obtained during the past season are shown in the accompanying table which gives the percentage of protein and carbohydrate found in early and late cuts of grass together with digestion coefficients obtained by digestion experiments with these samples :—

	Per cent Amount.	Crude protein		Carbohydrates		Amount digested
		Digestion Coefficients	Amount digested	Per cent. Amount	Digestion coefficients	
Aurangabad hay 1st cut.	4.16	34.5	1.43	80.2	52.1	41.8
2nd cut	2.58	11.5	0.30	80.6	51.1	41.2
3rd cut	1.66	..	..	81.5	47.9	39.0
Spear grass, 1st cut	5.60	41.9	2.35	82.2	55.9	47.1
(Bangalore) 2nd cut	3.18	13.8	0.44	85.6	49.2	42.1
Rhodes grass, 1st cut	11.38	59.4	6.76	76.9	64.7	49.7
(Bangalore) 2nd cut	6.26	41.2	2.58	83.4	58.0	48.4

The figures agree well with previous results confirming the conclusion arrived at regarding the relationship between digestibility and protein content of fodders. (Memoirs of the Department of Agriculture for August 1930, Volume XI, No. 4.)

In the tabular statement it will be noticed that the digestion coefficients for protein and carbohydrates increase as the protein content of the fodder increases.

The high protein content and the high digestibility of rhodes grass (protein and carbohydrates) compared with spear grass grown on similar land is noteworthy.

4. EXPERIMENTS WITH LEGUME HAYS

The work under this head consists of digestion and nitrogen balance experiments. The common legumes in use as or available as fodder in India are being examined. Tests have been carried out this year with ground nut hay, cowpea hay and lucerne.

A test to compare fresh lucerne and lucerne hay deserves notice. It is well known that losses in hay making are due partly to fermentation, partly to mechanical loss of brittle material. The combined losses are liable to be very serious.

This year for our experiments fresh lucerne was sundried on sheets in order to minimise mechanical loss.

The total loss in this operation is accurately known from weighments of the initial and final products and the moisture determinations (12 of each). The figures are as follows :—

	Weight. lbs.	% dry matter	Total dry matter. lbs.
Fresh lucerne	1,859	15.09	280.5
Lucerne hay (therefrom)	310	78.55	243.5

Here loss of dry matter due to conversion into hay is 37 lbs. or 13%. Having regard to the procedure employed, the mechanical losses probably only account for a small part of this total, which shows that fermentation may be considerable even under ideal conditions of conservation. There is no doubt that fodder conservation is an important subject requiring study in India.

The chemical composition and digestibility of fresh lucerne and the identical material converted into hay as above are shown in the accompanying table :—

	Crude protein	Ether extract	Fibre	Nitro- gen free extract	Total carbo- hydrates
Chemical composition. { Fresh lucerne	22.0	2.3	27.8	35.2	68.0
Corresponding hay	21.3	1.4	29.4	35.2	64.6
Digestible coefficients. { Fresh lucerne	80.0	45.8	49.7	72.3	62.3
Corresponding hay	77.0	29.7	50.0	67.9	59.7

There is practically no change in the chemical composition and only a very slight diminution in the digestibility. The results are unusually good.

5. MINERALS IN PASTURE GRASSES

This work to which Mr. Iyer has devoted attention for several years is beginning to yield important information.

The following tabular statement shows the mineral composition of three pure species of grass grown at Bangalore during two consecutive seasons.

Percentage mineral composition of grasses grown at Bangalore

Stage of maturity		1932.			1933		
		Before flowering	In full bloom	Dead ripe	Before flowering	In full bloom	Dead ripe
<i>Andropogon contortus</i> .	Ash	12.57	10.93	8.59	11.71	7.46	9.99
	Ash soluble in Hcl .	8.18	7.25	8.67	4.89	2.73	2.22
	P ₂ O ₅	0.628	0.428	0.188	0.317	0.158	0.159
	CaO	0.603	0.558	0.408	0.528	0.301	0.384
	MgO	0.407	0.417	0.295	0.300	0.224	0.206
	Na ₂ O	0.168	0.273	0.225	0.222	0.211	0.208
	K ₂ O	3.861	3.206	1.511	1.867	1.109	0.568
	Crude protein .	15.100	10.925	4.863	5.050	2.682	3.474
<i>Cynodon dactylon</i>	Ash	11.60	12.01	8.59	15.48	11.8	9.72
	Ash soluble in Hcl .	7.02	5.08	4.58	8.66	7.08	5.11
	P ₂ O ₅	0.508	0.474	0.302	0.641	0.549	0.245
	CaO	0.874	0.762	0.436	0.735	0.637	0.384
	MgO	0.377	0.269	0.426	0.390	0.355	0.254
	Na ₂ O	0.548	0.529	1.486	0.375	0.333	0.173
	K ₂ O	3.058	1.826	1.558	3.284	2.830	2.458
	Crude protein .	14.681	11.893	8.275	14.825	10.235	8.601
<i>Pennisetum cenchroides</i>	Ash	13.49	11.72	9.22	14.15	11.41	11.29
	Ash soluble in Hcl .	9.20	7.77	5.19	9.27	5.44	4.67
	P ₂ O ₅	0.671	0.501	0.306	0.634	0.444	0.469
	CaO	0.432	0.436	0.480	0.312	0.526	0.372
	MgO	0.368	0.432	0.451	0.333	0.340	0.337
	Na ₂ O	1.350	1.583	1.173	1.311	0.811	0.603
	K ₂ O	3.887	3.050	1.620	4.378	1.916	1.717
	Crude protein .	14.369	11.913	7.056	10.450	8.019	7.438

The first point to which notice is drawn is that while *Cynodon dactylon* and *Pennisetum cenchroides* are much alike during the two seasons, *Andropogon contortus* gave a very much richer product in 1932 than in 1933. This difference cannot be due to climate because the other two grasses show no such variation. The fact is that the *Andropogon contortus* was a new plantation in 1932 sown in very deeply and thoroughly cultivated land. The abnormally rich growth and mineral abundance of *Andropogon contortus* in 1932 must be accounted for simply and solely as the effect of cultivation.

It is an interesting and most important fact that cultivation may produce such a striking effect.

The second point to note is that the existence of certain specific differences in mineral assimilation are indicated and corroborated by data of two successive years.

For example, *Cynodon dactylon* has a tendency to contain more lime than the other species and the lime definitely exceeds the phosphoric acid.

- *Pennisetum cenchroides* contains less lime than *cynodon dactylon* and at times seems to contain more phosphoric acid than lime which is unusual.

6. DIGESTION OF FATS

In connection with this subject experiments have been carried out to test methods for determination of fat in foods and faeces.

In a series of tests, using petroleum ether as solvent, the amount of substance extracted in successive six-hour periods was determined. The following are typical results :--

Rate of extraction of fats, etc., from fodder and faeces with petroleum ether expressed in mgms. per 100 grams dry substance.

Period of extraction				Ragi straw	Faeces	Groundnut cake
I	6-hour period	.	.	459.4	951.6	9,894.0
II	"	.	.	46.6	41.6	52.0
III	"	.	.	23.3	31.2	10.4
IV	"	.	.	6.7	15.6	..
V	"	.	.	13.4	20.8	..
VI	"	.	.	13.4	10.4	..
VII	"	.	.	43.4	20.8	10.4
VIII	"	.	.	13.4	20.8	10.4
Next 60 hours				182.0	156.0	208.0
<i>Showing the incompleteness of extraction.</i>						
Official method for 16 hours				529.3	1,024.4	9,956.4
Subsequent 92 hours				272.3	244.0	228.8

It is quite possible that the fractions which are resistant towards the solvent are also resistant to the digestive juices. To clear up the matter extraction is now being undertaken on a larger scale.

To overcome the extraction difficulties, many authorities recommend alkaline hydrolysis. The Alkaline Hydrolysis method has been tested by the Nutrition Section, but for our materials it has not been found suitable.

Further tests are being made.

7. EXPERIMENTS WITH SHEEP

The main purpose of the experiments with sheep is to study the requirement and utilization of sulphur compounds.

This is a continuation of the experiments in which the Physiological Chemist showed that inorganic sulphate is assimilated by cattle.

The following typical data from the tests with sheep show that the animals are making use of inorganic sulphate to an appreciable extent. The utilization of sulphate is enhanced when a sulphate supplement is fed :—

Utilization of sulphate by sheep

Grams sulphur per day absorbed (+) lost (—)

Experiment No.	With sulphate supplement.	No supplement.
1	+0.069	—0.026
2	+0.155	+0.004
3	+0.179	+0.023
4	+0.192	+0.004
5	+0.204	+0.085
6	+0.215	+0.017
7	+0.298	+0.134

The following figures show that the ingestion of inorganic sulphate causes increase of organic sulphur :—

Increase of organic sulphur excreted in urine when a supplement of sodium sulphate is fed

Organic sulphur excreted in urine (grams per day)

Experiment No.	With supplement	No supplement
1	0.040	0.028
2	0.061	0.013
3	0.061	0.027

Maintenance requirements for sheep

The animals used for the sulphur metabolism experiments are virtually on a maintenance basis. They receive a small amount of groundnut cake and a little green fodder. The remainder of their requirements they take as they need from standard hay provided *ad lib.* The daily hay consumption is determined. With this rationing procedure the live weights of the animals have remained practically constant during six months. The amount of food consumed should be, therefore, a good estimate for the maintenance requirement of our Indian Sheep.

The figures are given in the accompanying table :—

Average food consumption in lbs. per day by sheep weighing 60·4 lbs.

Food	Consumption lbs. dry matter	Digested	
		Crude protein	S. E.
Green grass	0·251	0·009	0·073
Cake	0·110	0·053	0·096
Hay	1·247	0·000	0·337
Total	1·608	0·062	0·506
Total per 1,000 L. W.	26·6	1·28	8·38
Kellner standard (for coarse breeds)	18—23	1·0	8·3

Our starch equivalent corresponds closely with Kellner's standard but our food consumption has been somewhat higher.

8. PHYSIOLOGICAL STUDIES

(a) Acid-base balance

During the past year the work on this important subject has been devoted to the study of the influence of the maturity of the crop upon the acid-base balance.

The experimental fodders were fed to bullocks and the resulting urine examined.

In every case it was found that the early cut fodder produces the greatest volume of urine and the highest alkalinity. With later cuts the volume and the alkalinity both decrease.

The accompanying figures show the gradual change which takes place in the nature of the urine and in the acid-base balance as more mature fodder is fed :—

Per 100° gms. fodder

Total urinary excretion of acids and alkalis in c. c. N.

	Jowar Hay		
	1st cut	2nd cut	3rd cut
Alkalis	655.4	411.4	330.1
Chlorino	251.0	162.2	136.7
Sulphate	7.7	10.2	12.0
Organic acids	155.3	155.9	141.3
Total acids	414.5	328.3	290.0
Excess alkali	240.9	83.1	40.1
Carbondiaoxide	274.6	115.8	41.9
Ammonia	5.4	5.5	3.3
p ^H (urine)	7.90	7.60	7.40
p ^H (faeces)	7.60	7.35	7.25
Volume of urine excreted in litres per day .	5.964	4.131	3.543

With some overripe fodders decidedly acid urines were obtained and in one case there was a marked nutritional acidosis, the normal ammonia output being increased about ten fold. This was entirely due to the food.

(b) Blood Analysis

Work on the following lines has been in progress during the past year :—

- (a) A study of the influence of different fodders on blood Ca and P :—
- (b) Seasonal variation of blood Ca and P in cattle maintained under natural grazing conditions, with special reference to the relationship between blood minerals and breeding.

The influence of foodstuffs on blood Ca and P is shown in the following table of data obtained by the Nutrition Section during the past season :—

Ca and P Variations in Blood due to different fodders

Roughage	Maturity	Animal	mgm. Ca per 100 c.c. serum	mgm. P per 100 c.c. serum
Aurangabad hay	1st cut.	D	10.66	5.2
		E	10.98	4.95
	2nd cut.	D	11.04	5.23
		E	12.47	4.98
		D	12.97	4.85
	3rd cut.	E	13.42	5.53
Jowar hay	1st cut.	H	10.59	6.27
		V	11.70	5.88
	2nd cut.	H	10.78	5.53
		V	10.91	5.24
		H	12.37	6.51
	3rd cut.	V	12.86	5.64
Spear grass hay	1st cut.	C	11.31	5.24
		F	11.44	6.73
	2nd cut.	C	12.52	4.70
		F	13.81	6.26

It may be noted that with each foodstuff, the blood Ca tends to increase as the fodder becomes more mature.

It is a remarkable fact too that very similar values are obtained at each stage from all three fodders. There does not appear to be a corresponding regularity in the blood P but Aurangabad hay seems to give slightly lower values than the other fodders tested. Similar tests with various fodders showed that a certain sample of rhodes grass hay was quite unique in the abnormally high values for blood Ca which it produced (16—18 mgm. Ca per 100 c.c. serum). This point is being further investigated at present.

Some figures relating to seasonal variation of blood Ca and P are shown in the following table :—

Ajjampur Blood Samples—Ca and P (Mgm. per 100 c.c. serum)

Serial No.	Animal	March		April	
		Ca.	P.	Ca.	P.
1	Badagini . . .	13.27	5.70	11.67	6.30
2	Belevasavi . . .	13.14	4.24	12.95	7.74
3	Belegeji . . .	14.59	4.25	13.33	6.60
4	Chunchanagiri . .	13.93	3.99	13.01	8.59
5	Devagiri 8,25,16 . .	14.20	2.66	12.70	6.84
6	Devagiri 3,21,11 . .	12.41	4.54	12.05	6.95
7	Halithai . . .	13.07	5.84	12.12	7.32
8	Kalmari . . .	13.47	3.18	12.63	5.83
9	Masani . . .	12.87	4.02	12.50	7.38
10	Muthaide . . .	12.94	6.40	12.25	8.53
11	Ramgiri . . .	11.68	4.43	12.05	9.26
12	Smani . . .	15.05	4.10	13.53	7.06
	Average . . .	13.39	4.78	12.57	7.37

The noteworthy point in these figures is that a consistent rise in blood P has taken place at a time (April) when the P content of the natural herbage is falling to its lowest level. The main objective in this newly initiated work is to study the relationship between blood minerals and breeding a question of very great practical importance.

(c) Sulphur Partition in Grasses

Work on this subject has been in progress for some time. It is too early to discuss the data so far obtained.

IV. CO-OPERATION WITH OTHER DEPARTMENTS

(a) Military Farms Department.—As usual many valuable fodder samples have been provided by the Military Farms Department. Digestion and other tests have been carried out with this material.

(b) In the work on pasture grasses the section is receiving help from Pusa and also from Bombay, Bengal and Bihar and Orissa Departments of Agriculture.

(c) Very interesting work on blood composition is being carried out through the facilities offered by the Mysore Department of Agriculture. The same Department has also taken great pains to provide the Nutrition Section with fodder samples.

V. PUBLICATIONS

The following papers have been submitted for publication :—

1. Mineral Assimilation from two typical fodders.
 2. A Note on Powell and Whittaker's method for the determination of Pentosans.
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REPORT OF THE IMPERIAL MYCOLOGIST

(M. MITRA, M.Sc., Ph.D., D.I.C.)

(1) MYCOLOGICAL SECTION, PUSA

I. CHARGE

Dr. Mitra was in charge of the Section from 28th April, 1934.

II. DISEASES OF PLANTS

(i) SUGARCANE

The investigation of mosaic and other diseases of sugarcane which was formerly the major subject of the Section was completely transferred to the Mosaic Sub-Section financed by the Imperial Council of Agricultural Research, but substantial help was rendered by the staff of the main Section in the survey of mosaic disease, roguing, etc. A detailed account of this work is given in part 2 dealing with work done on mosaic and other sugarcane diseases under the Scheme mentioned above.

Tonnage experiment.—A paper entitled “Effect of Mosaic on the Yield and Juice of Sugarcane in Pusa, III” giving the result of last year’s (1932-33) investigations was published in the Indian Journal of Agricultural Science, Vol. III, Pt. V, 1933, pp. 870—880, and the experiments were continued under the guidance of Dr. W. McRae. The experiments were carried out on the same line as mentioned in the previous year’s report and a paper entitled “Effect of Mosaic on the Yield and Juice of Sugarcane IV,” giving the result of the year under review by Dr. W. McRae and L. S. Subramaniam has been submitted for publication.

(ii) WHEAT

Bunt disease.—The study of the bunt disease of wheat caused by *Tilletia indica* Mitra was continued by Dr. M. Mitra. The morphology and germination of spores was studied in detail and the biometrical analysis of spore measurement data of bunt from Karnal and Peshawar showed that there are at least two physiological

forms of *T. indica* the average diameter of spores of these two forms being $37.9 \times 32.5\mu$ and $36.2 \times 34.7\mu$ respectively. It has also been shown by a series of infection experiments done at Karnal and Pusa that infection does not take place at Pusa whereas at Karnal infection does take place. This is due to difference in climatic conditions. In order to determine the effect of some fungicides on the incidence of *T. indica* an experiment was carried out at the Botanical Sub-Station, Karnal, during the year. The fungicides tested were copper carbonate, ceresan, formalin and uspulun (universal). Untreated wheat seed was also sown as control, thus making up five treatments in the experiment. The three varieties of wheat used were Karnal-grown seed of Pusa 111, 112 and 113. There were two methods of infection, viz.—series A—naturally infected seed and series B—naturally infected seed *plus* an extra dose of artificial infection by shaking every 100 grams of seed with one gram of bunt powder. The experiment was carried out on a piece of land which was laid out in a randomized block system with eight replications. Each block contained thirty plots, each plot being $10' \times 5'$ in size, fifteen under infection series A, and fifteen under infection series B. There were five treatments and three varieties in each series. At the time of harvest the percentage of bunted ears in each plot was determined. The data obtained were statistically analysed according to Fisher's analysis of variance. It was noticed that infection in series B was significantly higher than in series A, that is, the extra dose of infection given in series B had definitely increased the percentage of bunt. It was further noticed that the percentage of infection can be reduced by treatment with the fungicides mentioned above but none is able to check the disease altogether. Uspulun (universal) gave the best results. The bunt spores are well protected especially in mildly attacked grain by the pericarp covering and the fungicides cannot reach the spores. Hot water treatment may perhaps be a possible method to check the disease to a greater extent and as loose smut is also very common, this one treatment would control both the diseases. There is an indication that, as in other bunts, infection can take place from infected soil and so a suitable rotation of crop is advisable. A paper entitled 'Stinking smut (bunt) of wheat with special reference to *T. indica*' was submitted for publication. Experiments will be carried out during the year to test the hot water treatment in controlling the bunt and smut.

Helminthosporium sativum P. K. & B. and *H. tritici-repentis* Died.—The percentage of leaf area destroyed by these two species of *Helminthosporium* was again estimated on varieties of wheat grown at Pusa and Karnal. At Karnal, the attack was much less during the year and with the exception of traces on a few varieties, it was absent altogether on other varieties of wheat. At Pusa the weather was very favourable for the disease, and the two fungi, especially *H. sativum*, were present in a severe form. There was a good deal of

variation in the percentage of attack, not only from plot to plot but also in the same plot. For instance in 1932-33 the range of percentage of leaf area destroyed in the case of Pusa 4 was from 12·7 to 23·3 with an average of 17·2 while in the Botanical Area it was from 5·3 to 9·3 with an average of 7·6. During the year under report the same variety in the Farm had a range from 23·7 to 27·1 with an average of 24·8 while in the Botanical Area the range was 17·1 to 34·4 with an average of 23·9. Other varieties behaved in a similar fashion. From the above example it will also be seen that the percentage of leaf surface destroyed by these fungi was far more during the year.

A paper entitled "A leaf spot disease of wheat caused by *H. tritici-repentis* Died." was sent for publication.

Loose smut of wheat.—The "loose smut of wheat" caused by *Ustilago tritici* (Pers.) Jens. was rather bad at Karnal especially on Punjab 8A grown round about the Botanical Sub-Station. Last year also the smut was very common on Punjab 8A and it is quite evident that all Pusa types grown at Karnal which were free from the disease got infection from spores blown from this wheat. The percentage of infected ears was determined and the following is an average of six counts :—

P. 4 —2·2%		P. 12 —1·7%
P. 80-5 —3·6%	P. 111 —0·49%	P. 112 —1·4%
P. 113 —0·49%	P. 120 —3·7°	P. 165 —1·4%
P. 114 —0·0%	Punjab 8A —24·2%	

Pusa 114 was found to be free from smut and it appears to be highly resistant to the attack of smut. As all the types may have been further infected from spores blown about from Punjab 8A, 258 maunds of various wheat varieties were treated for the Imperial Economic Botanist, Pusa, against smut by the solar heat method, that is, the seeds were soaked in water for four hours and then exposed to the solar heat for four to five hours during June when the atmospheric temperature used to go up as high as 120°F.

Wheat rust.—A survey of wheat rust on all the varieties of wheat grown in the Botanical Area and the Farm at Pusa and on all the varieties grown in the Botanical Sub-Station, Karnal, was again made during the year. The date of first appearance of three rusts during the last three years at Pusa was as follows :—

	1931-32	1932-33	1933-34
Orange	26-12-31	29-12-32	20-12-33
Yellow	16-1-32	3-2-33	19-1-34
Black	5-2-32	13-2-33	7-2-34

During the year all the three rusts appeared rather earlier and the attack by orange rust was more severe as compared with the previous year. The variety most affected was Pusa 12. The yellow and black rusts were mild in their attack. An estimate of the leaf surface covered by the rust pustules was made and the average percentage of leaf area by the orange and yellow rusts in all the varieties of wheat grown in Pusa is given below :—

Wheat varieties	Botanical Area		Farm Area	
	Orange	Yellow	Orange	Yellow
P. 4	Traces	..	Traces	..
P. 12	8.1	Traces	4.5	..
P. 52	1.28	.25	Traces	Traces
P. 111 . . . . .	.54	..	.20	..
P. 101	4.2	..	Traces	..
Federation . . . . .	..	..	..	..
Country	1.9	Traces	9.3	..
K. 12	5.4	..	..	..
K. 12-2	15.7	..	..	..

From the above table it will be noticed that the severity of attack varies in the same place, that is, P. 12 had 8.1 per cent leaf area affected by orange rust in the Botanical Area but had only 4.5 per cent in the Farm Area. P. 52 had 1.28 in the Botanical Area but only traces in the Farm. Similar variation is also noticed in other wheat varieties.

Orange and black rusts were slightly more prominent at Karnal during the year and yellow rust was as bad as last year especially on P. 52.

Aeroscopic slides for rust spores were again placed in wheat fields both at Pusa and Karnal for Dr. K. C. Mehta of Agra and exposed slides were sent to him at regular intervals from 15th September, 1933, to 15th March, 1934. Similar slides were also exposed for the Section at various places. Further help was given to Dr. Mehta by sending fresh specimens of rusts for his infection experiments. Infection experiments with rust material supplied by him were carried out on wheat seedlings to note the incubation period. A detailed report was supplied to Dr. Mehta.

(iii) RICE

Sclerotial diseases.—Experiments in plots highly infested with the sclerotia of *Sclerotium oryzae* Catt. (= *Leptosphaeria salvinii* Catt.) again gave negative results as the typical sclerotium disease was not seen. It did not appear in the pot experiments also but the plants in the latter were all sterile and the straw, on harvesting, showed the presence of sclerotia. It seems rather doubtful whether the fungus is parasitic under Pusa conditions. Unless the parasitism of the fungus can be demonstrated, there is not any purpose in studying the organism culturally and much progress with it has therefore not been made. Further pot and field tests have been undertaken by Dr. B. B. Mundkur.

Sclerotium oryzae did not develop the perfect stage reported from U. S. A., nor the *Helminthosporium sigmoideum* Cav. conidial stage. However tentative studies with the various isolations of rice Sclerotia have shown that aside from *S. oryzae*, there are three other *Sclerotium* species which do not so far seem to have been named. One sclerotium-forming fungus of the *Rhizoctonia* type seems definitely to be a new species, a view with which S. F. Ashby of the Imperial Institute of Mycology, Kew, agrees.

(iv) OATS

Smut diseases.—Smut appeared in a severe form in 1932-33 at Pusa and an investigation was undertaken with a view to control the disease. Examination of the smutted panicles showed that they were affected by covered smut, *Ustilago kolleri* Wille. Though this is the most common smut in India, strangely enough it has not been so far recorded even though an illustration of it is given in Butler's 'Fungi and Disease in Plants'. Examination of the Pusa Herbarium specimens showed that of the fifteen smut collections, only two were of Loose smut, *U. avenae* (Pers.) Jens. while all the rest were of Covered smut, but all bore the name, *U. avenae*. Samples of smutted panicles were subsequently obtained from Sind, the Punjab, United Provinces of Agra and Oudh, and Bihar and Orissa, and their examination made it manifest that covered smut is the predominant smut of oats in India.

The disease was brought under complete control by treating the seed with formaldehyde using the dry spray method. On a hundred acre area sown with treated seed, only two smutted heads were seen while on a twenty-five acre area sown with untreated seed, smut ranged from 1.5 to 16.9 per cent. In a well replicated test, treated seed yielded statistically higher quantity of grain than untreated seed. Two papers were written up by Dr. Mundkur and sent for publication and a leaflet on the dry spray method was written for the Bihar and Orissa Department of Agriculture.

(v) BARLEY

Helminthosporium sativum P. K. & B. was present in a virulent form during the year on several varieties of barley grown in the Botanical Area and the Farm and was responsible for the shrivelling and discoloration of the kernels. The spot formation due to this fungus was also noticed on the awns which became brownish and brittle and produced plenty of conidia. In several cases the seeds produced were totally destroyed by the fungus. An estimate of the percentage of leaf area destroyed by *H. teres* Sacc. and *H. sativum* P. K. and B. was again determined during the year on twenty-four types of Pusa barley and on other foreign and Indian varieties grown at Pusa. The combined percentage of leaf area destroyed by both species of *Helminthosporium* on twenty-four types of barley ranged from 4.6 to 23.9 as compared to 0.22 to 20.45 during last year. The infection due to *H. teres* and *H. sativum* ranged respectively from 1.1 to 20.7 and 1.1 to 16.8 as compared to 0.27 to 20.5 and 0.22 to 6.78 during last year and 0.5 to 25.4 and 1.2 to 14.2 during the previous year. Other Indian and foreign varieties had only *H. sativum* and the attack was severer than that of the previous year.

The experiment to test the comparative resisting power of twenty-four types of Pusa barley to the attack of species of *Helminthosporium* was repeated and in addition to uspulun (universal), cerasan was also used in the treatment of seeds. Altogether there were six treatments and each treatment had six replications, comprising 144 plots. All the seedlings which died of 'foot-rot' or 'root-rot' were removed twice a week and examined, when the crop was fully grown the percentage of leaf area destroyed and the yields were estimated. The efficacy of uspulun was again confirmed, and it was further noticed that cerasan is equally good in controlling the disease. Though both fungicides are good in controlling foot and root-rots, they cannot help in controlling the attack on leaf surface as a good deal of secondary infection takes place by means of air borne spores. All the data obtained are being statistically examined.

Smut.—The smut disease of barley caused by *Ustilago hordei* (Pers.) Kell. and Sw. is very common in Pusa and the surrounding areas and does a good deal of damage. During the year the seeds both in the Botanical Area and the Farm were treated with cerasan before sowing, and there was no sign of smut in the plots where treated seed was sown while in a plot where untreated seed was sown the smut was very bad. The efficacy of formalin, uspulun and cerasan to control the smut was tested on a small scale. Plots treated with cerasan and uspulun had no smutted ears while those treated with formalin had 0.5 per cent. of smutted plants as compared with the control (untreated) which had six per cent smutted plants.

Rust.—The yellow rust caused by *Puccinia glumarum* (Schm.) Erikss. and Henn. was present in a very slight form at Pusa on Types 1, 7, 9, 10, 12, 21 and 24 and all the other types were free. At Karnal, Pusa types 4, 13, 16, 18 and 21 and local 4 and 5 were grown. The yellow rust was bad on type 21 and all the rest were lightly attacked.

(vi) *HIBISCUS SABDARIFFA* L.

Sclerotinia stem-rot.—This disease again appeared this year in the first week of January confirming the previous year's observations that it is primarily a cold weather disease. Trials to see whether the plants would mature and set seed earlier if sown earlier gave disappointing results, for seed sown in April, May, and June flowered almost at the same time and plants were ready for harvest at the same time also, viz., end of February. It was noted that *sclerotia* when buried in the soil at a depth of three, six and nine inches, did not form apothecia but those buried at a depth of one inch and those that were placed on the surface of the soil developed them. Ploughing in the soil rather deep after harvesting the Hibiscus crop is therefore one of the methods of controlling this disease, for experiments have shown that the disease is brought about only by the ascospores that are formed about December when the cold weather sets in. *Sclerotia* of an authentic culture of *Sclerotinia sclerotiorum* (Lib.) de Bary, *S. minor* Jagger and *S. intermedia* Ramsay formed apothecia. The Hibiscus *Sclerotinia* agreed with *S. sclerotiorum* and spore measurements further confirmed this conclusion. The investigation was brought to a conclusion and a paper by Dr. Mundkur was sent for publication.

(vii) *CROTALARIA JUNCSEA* L.

Wilt disease.—The study of the wilt disease of *Crotalaria juncea* caused by *Fusarium vasinfectum* Atk. was continued by Dr. Mitra. The fungus can be noticed on pods and in many cases on the seeds in diseased pods. Wilted plants have been found to produce large number of immature seeds and these seeds have the infection and are capable of disseminating the fungus at the time of threshing, thus infecting mature, viable and healthy seeds. As a certain percentage of wilt of sann-hemp is caused by the fungus carried by seed, it is advisable to disinfect the seed before sowing with some fungicides such as, uspulun (universal, 0.25 per cent.) for thirty minutes or mercuric chloride (1-1000) for ten minutes.

Infection experiments with sann-hemp and pigeon-pea *Fusarium* were repeated and the previous years' results were confirmed. The experiments carried out showed that sann-hemp and pigeon-pea wilt are caused by similar strains of *F. vasinfectum* under Pusa conditions and that sann-hemp strain of *Fusarium* can infect pigeon-pea but not cotton or sesamum, and the pigeon-pea strain can infect sann-hemp but not cotton and sesamum.

There appears to be a close association between soil temperatures and maturity on the one hand and incidence of *Fusarium* wilt in sann-hemp and pigeon-pea on the other, that is, the same fungus causes wilt in these two crops under two different sets of conditions. In sann-hemp high temperature favours the wilt while low temperature seems to favour wilt in pigeon-pea.

Infection experiments with *Rhizoctonia solani* Kuhn and *Neocosmospora vasinfecta* Smith isolated from wilted sann-hemp plants were repeated in sterilized soil and pathogenicity under local conditions was proved. In nature these two fungi produce wilt but to a minor extent. *Rhizoctonia solani* is generally found in young wilted plants. A paper entitled "Wilt disease of *Crotalaria juncea*" has been sent for publication.

Cercospora sp.—A species of *Cercospora* forming spots on the leaf, stem and pod of sann-hemp was found to be very common in Pusa. A single spore culture was obtained and infection experiments carried out proved its pathogenicity. It failed to produce the disease when cross inoculated on *Phaseolus aconitifolius*, *P. radiatus*, *P. mungo*, *Vigna catjang*, *Cajanus indicus*, *Stizolobium* sp. *Cyamopsis psoraliodes* and *Glycine hispida* and thus appears to be restricted to sann-hemp only. From the study of morphological and cultural characters by Mr. Udai Bhan Singh, it appears to be an undescribed species. A *Cercospora* sp. has also been recorded from Trinidad but does not seem to have been studied in detail.

(viii) PIPER BETLE.

Foot-rot diseases of Piper betle in Bengal. In Bengal the 'foot-rot' diseases of betel vine are caused by three fungi, *Rhizoctonia solani* Kuhn, *Sclerotium rolfsii* Sacc. and *Phytophthora parasitica* Dast. The major loss to vine growers during the monsoon is due to the *Phytophthora* but just after the rains and in the early part of winter, the foot-rot is mostly due to *R. solani*. Only stray cases of *S. rolfsii* have so far been noticed in this delta. Flooding seems to promote the disease to a considerable extent, for in areas above the flood level and in years of scanty rainfall the disease does not cause so much loss. Warm summer temperatures are favourable for the growth of *Phytophthora* when it does the maximum damage while slightly cooler temperatures favour the growth of *R. solani*. Growing the vines above the flood level, clean culture and timely application of two fungicides, Bordeaux mixture and Kerol, control the disease. A large number of infection experiments were carried out on castor oil seedlings with various strains of *Phytophthora* isolated from betel vines. All took infection and produced spots on leaves. The measurements of sporangia under standard conditions were statistically analysed and the investigation was concluded and a paper entitled 'Foot-rot disease of *Piper betle* in Bengal' was sent for publication by Dr. W. McRae.

(ix) PHASEOLUS SP. AND OTHER PULSES

Cercospora sp.—A comparative study of the species and strains of *Cercospora* isolated from *Phaseolus aconitifolius*, *P. radiatus*, *P. Mungo*, *Vigna catjang*, *Stizolobium* sp. and *Cyamopsis psoralidodes* was continued by Mr. Udai Bhan Singh with a view to determine whether there are a number of species or merely strains of a single species. The H-ion concentrations, the temperature relationships, the effect of light and darkness, the amount of medium and the zonation were studied. The spore size and septation on a number of media and at different temperatures were also measured. The study of the saltants obtained during the course of the study was concluded. A paper entitled "A comparative study of the species and strains of *Cercospora* parasitic on pulses" is being written up.

A species of *Cercospora* parasitic on the leaf, stem and pod of *Glycine hispida* (soy-bean) was isolated and a detailed study was made. The morphological and cultural characters do not agree with *C. daizu* Miura known to cause 'Frog eye leaf spot' of soy-bean. All the varieties of soy-bean grown at Pusa were found to be susceptible to its attack. In severe cases the infection of the seed also takes place and the disease appears to be seed borne.

Colletotrichum sp.—A comparative study of the species and strains of *Colletotrichum* from various pulses and other hosts with a view to determining of the number of species and strains was started and single spore cultures were obtained from *Phaseolus aconitifolius*, *Dolichos lablab*, *Cajanus indicus*, *Glycine hispida*, *Vigna catjang*, *Phaseolus radiatus*, *P. Mungo*, *Stizolobium* sp. *Piper betle* and *Panicum frumentacium* and several of the isolates formed the perfect stage (*Glomerella*) in culture.

(x) CICER ARIETINUM L.

A survey of gram blight caused by *Myrothecium* sp. was made on eighty-four varieties of gram grown in the Botanical Area. The blight was very bad on Type 68 and in a fair amount on Types 48, 49 and 67. On eighteen types the attack was slight and on thirty-four types it was present only in traces and the rest were free from the disease.

Methods of control were again studied. Seeds treated with formalin, uspulun (universal), sulphur and cerasan were sown using Types 68 and 69 but unfortunately the earthquake of 15th January, 1934, destroyed practically the entire experiment by the deposition of sand through fissure.

(xi) TOBACCO

Stem-rot.—The investigation on the stem-rot disease of tobacco caused by *Sclerotinia sclerotiorum* (Lib.) de Bary was continued by

Mr. K. F. Kheswalla. Inoculation experiments carried out showed that infection can be brought about by whole or cut sclerotia as well as by ascospores. The fungus was studied in detail in culture and a paper entitled 'A stem-rot disease of tobacco' has been sent for publication.

Root-rot.—A disease of tobacco in which the leaves become yellow and later on turn brown was noticed at Rangpur (Bengal). The infected plants showed the symptoms of wilting and an examination of the underground parts showed that the root system was poorly developed, brittle, and in advanced cases rotting. Microscopic examination revealed the presence of a *Fusarium* which was isolated. The pathogenicity of this fungus is under investigation.

(xii) AMOMUM SUBULATUM ROXB

Phurki disease.—This disease which came to the notice of the department in 1909 has been doing much damage to the greater cardamom in the Darjeeling District and the cultivation of the crop has almost become impossible. It is primarily a disease of the roots and when these are affected, the plants put on a very unthrifty appearance; the leaves curl up and the plants soon become sterile and fail to bear seed. In some of the affected roots a species of *Cephalosporium* has been noticed by Dr. Mundkur but it remains to be seen whether it is pathogenic or whether the disease is not a sort of degeneration disease of the virus type, something like the "Katte" disease of Kanara cardamom (*Elettaria cardamomum* M. and W.).

(xiii) FRUIT TREE DISEASES

A survey of diseases of fruit trees in British Baluchistan was again undertaken during the year and the following fungi in addition to those mentioned in the previous year's report were recorded by Mr. Kheswalla for the first time:—

Almond	. . . . .	<i>Alternaria</i> sp. (leaf-spot), <i>Coniothecium</i> sp. (leaf-spot), <i>Oidiopsis</i> sp. (mildew) and <i>Cytospora</i> sp. (Die-back).
Apple	. . . . .	<i>Oidium</i> sp. (mildew) and <i>Cytospora</i> sp. (bark canker of seedlings).
Peach	. . . . .	<i>Alternaria</i> sp. (leaf-spot), <i>Coniothecium</i> sp. (leaf-spot), <i>Rhizopus</i> sp. (Fruit-rot) and suspected cases of yellow.
Pear	. . . . .	Die-back (Physiological).
Walnut	. . . . .	<i>Cytospora</i> sp. (Die-back).

The species of *Cytospora* do a good deal of damage to apple, almond and walnut. They are responsible for the formation of

canker in apple tree and die-back in almond and walnut. The symptoms of the three species on their respective hosts were studied and isolations made for comparative study.

Soft-rot of Peach.—A species of *Rhizopus* was isolated from peach fruits attacked with soft-rot disease. Infection experiments carried out on healthy unwounded peach fruits showed that it is capable of producing rot of peach.

Soft-rot of Apple.—A species of *Alternaria* was isolated from diseased apple and infection experiments carried out showed that in addition to causing soft-rot in wounded apples during transit, the fungus is capable of infecting healthy fruits as well.

Leaf-spot of Grape vine.—A leaf-spot disease of grape vine is very common in Pusa and a fungus which resembles *Guignardia* sp. was isolated. The fungus forms irregular, light brown to dark brown spots. Infection experiments carried out proved its pathogenicity. A single pycnospor culture has been obtained and the fungus is being studied in detail.

Black-rot of Chestnut.—Black-rot of chestnut fruits causes a good deal of damage to chestnuts in Kulu (Punjab). The surface of the diseased fruits become bluish black and the affected portion become brittle. In severe cases the discoloration extends deep into the tissue. The infection appears to take place at the stalk end of the fruit. A species of *Sclerotinia* and a species of *Cytospora* have been isolated. The former organism develops Botrytis stage in culture. A single conidium culture gave rise to sclerotial formation.

III. MISCELLANEOUS

Sclerotium rolfsii Sacc.—Studies on the growth of this fungus have been continued by Dr. Mundkur. Appearance of the *Corticium* stage once in culture was mentioned in the last year's report. In an agar medium containing an infusion of onions, proteose peptone and asparagin, this stage appeared in abundance in four strains and single sporidial cultures were obtained which grew into typical sclerotia, thus demonstrating genetic connection between the *Corticium* stage and the Sclerotial stage. It was also found that unless the temperature is around 31°C., the hymenium does not form the basidiospores. Further studies are in progress.

Several *Sclerotium* species isolated from Betel vines (*Piper betle*) and tentatively referred to *Sclerotium rolfsii*, have been examined further. One isolate is definitely *Sclerotium delphinium* Welch, a culture of which was obtained from the Imperial Institute of Mycology, Kew. There is another *Sclerotium* which differs in several respects from *S. rolfsii* and *S. delphinium* and it may possibly be a new one. A paper regarding the perfect stage, has been sent for publication.

Cercospora tageticola Ell. et E. infecting leaf stem and inflorescence of *Tagetes patula* was observed for the first time. The disease was in an epidemic form. It is carried from diseased flowers to healthy flowers by means of honey bees which are the only insects visiting the flowers of *Tagetes patula*. Spores of this fungus were found sticking on the legs, wings and mouth of the honey bees.

A study of the fungus flora of pigeon-pea sick soil where pigeon-pea has been grown for the last ten years and the soil is heavily infected with *Fusarium vasinfectum* Atk. was undertaken by Mr. Udai Bhan Singh. *Fusarium vasinfectum* was found to be present in the soil at a depth of two feet. Several other fungi were found to be common especially species of *Aspergillus*, *Neocosmospora vasinfecta* Smith, and *Mucor*. Three Ascomycetes, viz., *Delitschia* sp., *Magnusia* sp. and *Orbicula* sp. were also found in plenty. The number of colonies of fungi decreased with the depth.

Moisture contents of a typical sugarcane plot were determined regularly at an interval of one week till 15th January, 1934, when it became impossible to continue on account of the earthquake. The temperature of soil at a depth of six inches and twelve inches was recorded for the year and other meteorological observations taken in order to apply them to the incidence of a particular disease during a particular period.

IV. SYSTEMATIC WORK

The following fungi were recorded for the first time :—

<i>Sorghum margaretiferum</i> DC	<i>Phyllachora sorghi</i> v Hoehn (Pattambi, Madras)
Oats	<i>Epicoccum neglectum</i> Desm (Sabour).
Tobacco	<i>Phytophthora parasitica</i> var. <i>nicotianae</i> Tucker from the stem and roots (Anakapalli, Madras).
<i>Panicum frumentaceum</i>	<i>Colletotrichum</i> sp. on leaf and leaf sheaths. (Pusa).
Sugarcane	<i>Ceratostomella paradoxa</i> (de Seynes) Dadé (Coimbatore), <i>Sclerotium rolfsii</i> Sacc. (Tahpuramba, Madras), <i>Cercospora kopkei</i> Kruz. Ber. Zuck (Burma).
<i>Hibiscus sabyrdariffa</i> L.	<i>Colletotrichum</i> sp. and <i>Fusarium</i> sp. from stem affected with canker (Pusa).
<i>Anona squamosa</i>	<i>Pleosphaeropsis</i> sp. (Pusa).
<i>Stizolobium</i> sp.	<i>Cercospora</i> sp. (Pusa).

The identification of species of *Daldinia concentrica* on various hosts was revised and corrected. Fifty-one specimens of various fungi belonging to Ascomycetes were supplied to Dr. H. Sydow,

Berlin. Four specimens and two cultures to the Principal, Agricultural Institute, Allahabad, two specimens and two cultures to the Professor of Botany, Allahabad University, one culture to the Government Mycologist, Nagpur, two specimens and one culture to the Professor of Botany, Bethune College, Calcutta, three specimens to the Rice Specialist, Bihar and Orissa, and one specimen and two cultures to the Professor of Botany, Carmichael Medical College, Calcutta, were supplied. Thirty-one specimens from the Professor of Botany, Allahabad University, 200 from Dr. H. Sydow, Berlin, and eight from the Mycologist, Indian Tea Association, Assam, were received for our herbarium.

A large number of cultures were received from various workers in Agricultural Departments and Indian Universities for identification and where required remedial measures were suggested.

During the last few years 2,625 fungi from different sources or collected by the staff have been added to the herbarium, and attempts are being made to complete the revised "List of Mycological Specimens in the Herbarium." A large number of half named specimens were taken in hand to have them fully identified.

A good deal of assistance was given to the Bengal and the Bihar and Orissa Departments of Agriculture in the investigation of diseases of several crops.

The Section was also useful to a number of investigators in Mycology and Plant Pathology in other directions, *e.g.*, by supplying descriptions of fungi and literature pertaining to the subject on which they are working. A list of fungi causing diseases of potatoes and other tuber crops grown in India was prepared and sent to the Imperial Chemical Industries (India), Ltd.

V. PROGRAMME, 1934-35

1. RESEARCH, WORK

Owing to the earthquake of January 15, 1934, the work of the Section has been considerably dislocated and normal working cannot be resumed until the Section is properly housed. New diseases of Indian crops that come to the notice of the Section will however continue to be investigated. Diseases of the following crops will receive special attention :—Wheat, oats, barley, rice, tobacco, linseed, pulses and potatoes. The diseases of sugarcane will be investigated under Scheme of Imperial Council of Agricultural Research.

The investigation in progress include :—

1. Investigations on smuts of oats and barley.
2. A study of the bunt disease of wheat caused by *Tilletia indica* and remedial measures.

3. Studies on sclerotial and other diseases of rice.
4. A study of the diseases of cultivated grasses caused by species of *Helminthosporium* and determination of percentage of rust and *Helminthosporium* on various varieties of wheat and barley.
5. A comparative study of various strains of *Sclerotium rolfsii* and *Rhizoctonia* on various hosts including potatoes.
6. A comparative study of *Colletotrichum* on pulses and other crops.
7. Investigation on diseases of tobacco.

2. TRAINING

Students and assistants will receive training on the lines indicated in the prospectus.

3. ROUTINE WORK

Advice and assistance as required will be given to other departments and the general public.

VI. PUBLICATIONS

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| Kheswalla, K. F. | Stem-rot of tobacco caused by <i>Sclerotinia sclerotiorum</i> (Lib.) de Bary. [<i>Ind. J. Agr. Sci.</i> , Vol. IV, Pt. IV, Aug. 1934.] |
| McRae, W. | Effect of Mosaic Disease on the Tonnage and the Juice of Sugarcane in Pusa, Pt. IV. [<i>Ind. J. Agri. Sci.</i> , Vol. IV, Pt. V, Oct. 1934, pages 787—796.] |
| / Do. | Foot-rot diseases of Piper betle Linn. in Bengal. [<i>Ind. J. Agri., Sci.</i> Vol. IV, Pt. IV, Aug. 1934, pages 585—617.] |
| \ Mitra, M. | Wilt disease of <i>Crotalaria Juncea</i> Linn. (Sann-hemp.) [<i>Ind. J. Agri., Sci.</i> Vol. IV, Pt. IV, Aug. 1934, pages 701—714.] |
| / Do. | A leaf-spot disease of wheat caused by <i>Helminthosporium tritici-repentis</i> Died. [<i>Ind. J. Agri. Sci.</i> , Vol. IV, Pt. IV, Aug. 1934, pages 692—700.] |
| / Do. | Stinking smut (bunt) of wheat with special reference to <i>Tilletia indica</i> Mitra. [<i>Ind. J. Agri. Sci.</i> , Vol. V, Pt. I, Feb. 1935.] |
| / Do. & Mehta, P. R. | Diseases of <i>Eleusine coracana</i> Gaertn. and <i>E. Aegyptiaca</i> Desf. caused by species <i>Helminthosporium</i> . [<i>Ind. J. Agri. Sci.</i> , Vol. IV, Pt. VI, Dec. 1934, pages 943—975.] |

- Mitra, M. & Mehta, P. R. . . . The effect of Hydrogen-ion concentration on the growth of *Helminthosporium nodulosum* B. et B. and *H. leucostylum* Drech. [*Ind. J. Agri. Sci.*, Vol. IV, Pt. V, Oct. 1934, pages 914—920.]
- Mundkur, B. B. . . . A Sclerotinia-rot of *Hibiscus sabdariffa* Linn. [*Ind. J. Agri. Sci.*, Vol. IV, Pt. IV, Aug. 1934, pages 758—778.]
- Do. . . . Perfect stage of *Sclerotium rolfsii* Sacc. in culture. [*Ind. J. Agri. Sci.*, Vol. IV, Pt. IV, Aug. 1934, pages 779—781.]
- Do. . . . Influence of temperature and maturity on the incidence of Sann-hemp and Pigeon-pea wilt at Pusa. (Submitted for publication).
- Do. . . . Oats smuts in India. [*Ind. J. Agri. Sci.*, Vol. IV, Pt. IV, Part V, Oct. 1934, pages 895—898.]
- Do. & Azmatullah Khan . . . A Dry Spray method of treating oat seed against covered smut. [*Ind. J. Agri. Sci.*, Vol. IV, Pt. IV, Part V, Aug. 1934, pages 899—905.] Popular abstract also published as pamphlet by Bihar and Orissa Dept. of Agriculture.
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12) SCHEME FOR RESEARCH ON MOSAIC AND OTHER DISEASES OF SUGARCANE

(Financed by the Imperial Council of Agricultural Research)
1933-34

(S. V. DESAI, B.Sc., PH.D.)

I. INTRODUCTION

The earthquake of 15th January 1934 disorganized the work but it has been possible to improvise laboratory accommodation in which work could be continued.

II. MOSAIC DISEASE

A. *Distribution*.—The occurrence of mosaic was noted on the following varieties in addition to those previously recorded:—

Shahjahanpur—Co. 331, 343, 347, 350, 360, 400, 401, 402, E. K. 28.

Padegaon—P. O. J. 2878, H. M. 607 and 609, and Elephant grass.

Jullundar—Co. 331, 356 M 2 and "Mogal".

B. *Natural spread*.—A row of each of the following thirty-six varieties was planted at Pusa alternately with a row of mosaic-infected Co. 213:—

Co. 213, 214, 281, 285, 290, 299, 303, 312, 313, 316, 327, 331, 341, 342, 343, 344, 345, 346, 347, 348, 349, 351, 356, 387, 388, 393, 395, 396, 397, Tuc. 393, 472, P. O. J. 2878, Saretha, Uba and Lalgirah, with a view to test the natural spread of mosaic in them. The disease did not appear in any of the varieties till the end of June 1934. The spread of the disease from March 1933 to February 1934 was noticed on Co. 301 (1 clump), Co. 313 (3 clumps) and Saretha (1 clump).

It has been noticed in previous years that the mosaic canes of Co. 213 did not give cent per cent mosaic plants. The result of germination of selected mosaic canes of Co. 213 in previous years is given below:—

1931-32	63.41,	1932-33	66.86 and 1933-34	78.50.
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An experiment has been laid out to find what percentage of mosaic plants develop when mosaic setts of various varieties are planted. Further, whether the healthy plants developing out of mosaic setts continue to reproduce healthy canes is also being studied.

The spread of mosaic in Co. 213 from mosaic canes of the tonnage experimental plots to the adjoining healthy plots has been very small at Patna Farm. Only three clumps in two of the healthy plots were found to have mosaic by secondary infection at Patna and two clumps of similar mosaic infection were found at Cawn-pore Farm. The Plant Pathologist, Cawnpore, reported that the spread of mosaic from diseased Ponda cane to healthy Ponda cane grown on that farm was so much that most of the healthy cane plots were infected and the experiment on the effect of mosaic on tonnage of Ponda was ultimately abandoned. Thus it appeared that the rate of natural spread in different varieties varied at one and the same place.

At Padegaon, where in previous year P. O. J. 2878 was free from mosaic, this year some of the plots of P. O. J. 2878 had considerable mosaic, the infection being as high as 12 per cent. in one of the plots. The setts with which these plots were planted were obtained from the same farm and were mosaic-free. The ratoon left after the removal of the crop for planting also showed no disease, thus making it doubly certain that the disease was not seed borne. The only disease on the farm during the previous year was two clumps of mosaic in H. M. 213 in the museum, and it is highly improbable that this had been the source of the present infection. During the year some elephant grass was imported from the Gokak Farm and the grass was found to be completely affected by mosaic. This being the only outside source of mosaic on the farm it is presumed that the disease spread from this to P. O. J. 2878 variety which was planted near by. The spread was found to be considerable and rapid which showed that the insect vectors had a favourable climatic condition for spreading the disease. Here it was noticed that the mosaic did not spread to Ponda canes grown near the diseased grass. They have been immune so far. No case of mosaic has yet been found in Ponda in the Deccan.

C. Roguing.—The whole area of 28·5 acres under sugarcane in the Pusa Farm was rogued and the varieties affected with the disease with the area under cultivation were as follows :—

Area	Variety	Clumps infected	Per cent. infected
13·84 acres	Co. 213	2	·001
2·467	Co. 281	4	·012
5·19	Co. 299	4	·006
0·62	Co. 344	2	·025

There were seventeen varieties under field conditions and fifty-six varieties in the nursery, and the disease was negligible. It thus appeared that by careful roguing, the mosaic was held in check as well as eliminated from most of the Coimbatore varieties.

D. *Artificial Transmission*.—It has been noticed that it is possible to transmit mosaic from one variety to another and further to jowar (*Andropogon sorghum*), *Euchlaena mexicana* and maize by infecting them with the juice of sugarcane mosaic leaves, but the reverse transmission of mosaic from jowar, *Euchlaena* and maize has not been possible.

The virulence of the mosaic virus has been noticed to vary with the climatic conditions and at Pusa the virus is of sufficient virulence for artificial transmission from 15th March to 15th June only.

The action of various chemicals on the virulence of the mosaic juice was studied. For this purpose the mosaic leaf juice was filtered through cheese cloth and the appropriate quantities of the chemicals were allowed to act for twenty minutes; the juice was then inoculated into a batch of young plants and the transmission of the disease noted. HNO_3 (1 c. c. in 800), HCl (1 c. c. in 1,000), NaCl (1 in 25), HgCl_2 (1 in 1,000), $\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$ (1 in 1,500), H_2O_2 12 vol. (1 in 25), formalin (1 in 50), inactivated the mosaic virus. These chemicals in lower concentrations did not inactivate the virus. Zinc powder and MnO_2 (1 in 20) did not retard the activity.

Effect of dilution.—Fresh sugarcane mosaic leaves were ground up with equal amount of water and the juice extracted through a cheese cloth. This juice was used as the standard. Ordinarily 50 gms. of leaves with an addition of 50 gms. of water gave 45 gms. of the standard juice. This was immediately diluted to appropriate strength and inoculated into a batch of plants in 10 pots. The result showed that dilutions beyond 1 : 10 were too dilute for infection. Thus the concentration and virulence of the virus was found to be very weak. With dilutions of 1 : 10 and less, the disease appeared in the inoculated plants.

The effect of ageing was also studied. The standard mosaic juice was kept at 20°C . for various lengths of time and inoculated into a batch of potted plants after different intervals. The time was measured from the moment of extraction of the juice. One hour after extraction the juice had the infective power but beyond that time it seemed to be inactivated. Thus the time the mosaic juice remains infective after extraction is very limited.

Experiments were carried out to test the filtrability of the mosaic juice. The standard mosaic juice was repeatedly poured in the same filter funnel till the filtrate was clear brown liquid. The paste left on the filter paper was well washed and suspended in distilled water and filtered on another filter paper. The washed paste and the clear filtrate were inoculated into the test plants. The filter paper filtrate was found to be non-infective while the washed green paste was found to be infective. It thus appeared that the infective principle remained more or less adsorbed on the

fine tissue particles and that the infectivity was lost even by filtration through a filter paper. Chamberland candle filtrates were not infective. But the serological tests in which the Chamberland candle filtrates were used to immunize the rabbits suggested that the virus did pass through the candle inasmuch as the immune serum inactivated the mosaic leaf juice.

E. Nature of mosaic virus.—Further work on the organisms associated with mosaic was carried out, cumulative evidence pointing to the filterable forms of these organisms as being closely allied to the virus. Isolations of the same type of organisms were made when sterilized pieces of infected sugarcane were placed on nutrient agar. The growth was observed to occur after a fortnight to a month. Healthy tissues similarly placed failed to show any growth. Occasional contaminations did take place but these were clearly seen as the growth in such tubes invariably occurred during the first few days after sealing the tubes containing the tissues. Further, ageing the diseased leaf juice after filtration through Chamberland filter candles for a month or so, then implanting it on agar medium and transferring the invisible film on the agar surface by washing it with a drop for two of nutrient broth induced the growth of this type of organisms after a few such transfers.

The effect of the age of the diseased plants on the number of transfers necessary to obtain visible growth was studied and it showed that with the advent of the monsoon the isolation became more protracted till the weather again became dry and hot. It was interesting to find that the virulence of the virus as measured by the relative chlorophyll contents followed a similar course and the disappearance of mottling on the leaves suggested the attenuation of the virulence of the virus during the monsoon. Difficulties of maintaining the cultures of these organisms were considerable as the transfers unaccountably failed to give visible growth and could not be revived even after a long series of passages in broth. The organisms were peculiar inasmuch as they gave all negative biochemical reactions and were unstable in their visible forms. The relative lengths of various cyclostages of these organisms were compared with those of *Shiga Bacillus* (in which filterable forms and other cyclostages are well studied). This established that these organisms were most stable in the "virus" cyclostage :—

	Bacterial cyclostage " R. & S" stage	Filterable cyclostage " g " form	Virus stage invisible growth stage
<i>Shiga Bacillus</i> . . .	1	26	02
<i>Mosaic virus organisms</i> . .	1	2	22

As direct evidence of the filterable forms of these organisms being the cause of the disease was unobtainable probably due to the virulence for plants being lost during the growth in vitro, indirect evidence was sought to prove the relation of the filterable forms to the virus producing the disease. For this purpose the virus (mosaic juice filtered through candle), the filterable forms of the organisms and the healthy juice (filtered through candle) were injected intravenously in successively increasing doses in rabbits and the serological reactions produced by these various antigens were studied. This brought out the close relationship between the filterable forms of the organisms and the virus.

If the serum produced by the virus or the filterable forms was mixed with the juice of mosaic leaves the virus was inactivated as evidenced by its failure to produce the disease in the two series of plants inoculated with the mixture while the mosaic juice mixed with serum produced by the organisms or the healthy juice failed to neutralize the virus as evidenced by the disease appearing in most of the twenty pots inoculated with the mixture. As the same mosaic juice was used for the above experiments, and had its own virulence separately tested, it is evident that the antibodies produced in the sera by virus and filterable organisms neutralized the virus. Thus the filterable forms of the organisms appeared to be similar if not identical to the virus.

Further the agglutination tests against the organisms also supported this conception :—

The results were confirmed by immunizing a fresh batch of rabbits which also gave similar results when sera were tested.

Complement fixation tests, Hemolysin reaction, and precipitation tests, also gave support to the agglutination results, and these in conjunction with the "in vitro" inactivation of the virus gave a strong support to the view that filterable forms and the virus were closely related.

Dilutions		1:100	1:300	1:400	1:800	1:1600	1:2400	1:3200	1:4800
Virus serum .		++++	++++	++++	+++	++	+	...	...
Filterable serum.	form	++++	++++	++++	++++	+++	++	+	...
Bacterial serum		++++	++++	++++	++++	+++	+	..	...
Healthy serum.	juice	+	+	...	...	...	...	...	..

The use of the immune sera for prophylactic purposes in plants was tried and it was found that these did not confer immunity; further investigations are yet required to settle this point definitely.

F. Chlorophyll changes.—The relative amount of chlorophyll in healthy as well as mosaic leaves was studied at different times of the year in two varieties of sugarcane namely Co. 213 and Saretha, a local variety. This clearly showed that the plants recovered from the bad effects of mosaic from monsoon onwards. Thus the bad effect of mosaic on the yield is limited by the set back in growth during the periods of high virulence which are not very long under sub-tropical conditions. Further more, the experiment showed that climatic conditions have a major influence in determining the damage due to mosaic on the crop. This explained why the loss of tonnage due to mosaic varied in different years and why the reduction in yields was not so very great as in some other tropical countries. The relative percentage of chlorophyll in mosaic as compared to healthy leaves are given below :—

Date	13/7	4/8	5/9	20/9	17/10	27/11
Saretha	69.7	74.8	86.1	93.4	97.4	95.2
Date	28/7	11/8	30/8	15/9	16/10	24/11
Co. 213	69.7	78.1	80.6	78.0	71.8	86.1

The estimations of chlorophyll were carried out by extracting equal areas of mosaic and healthy leaves in hot 85 per cent. alcohol under identical conditions. Equal areas of leaves were removed by punching out from the leaves of the same growth and age. The amounts extracted were compared in a Dubosque colorimeter.

Leaf to leaf variation of chlorophyll in mosaic and healthy leaves followed the same course. Topmost leaves were very poor in chlorophyll. Old dying leaves also showed little chlorophyll the functioning leaves were 2nd from the top to 9th. The 4th and 5th leaves had the highest amount of chlorophyll. The difference in the percentage in mosaic as compared to healthy leaves was most marked in 4th leaf in Co. 213 and 3rd leaf in Saretha.

G. Tonnage experiment.—The experiment on the effect of mosaic on the yield and juice of sugarcane was carried out at Pusa. Thirty-six plots, each 5 by 56 yards of Co. 213 were laid in adjacent pairs, half of them with mosaic-free and half with mosaic-infected canes in the order as follows :—

Mosaic-free, mosaic-infected, mosaic-infected, mosaic-free and so on. A very small amount of infection spread to the mosaic-free plots; altogether seven clumps were affected by mosaic, seven

plots having one clump each. This very small spread to healthy canes in such close juxtaposition to mosaic-infected canes indicated how few and inactive insects were during the season in spreading disease. The mean percentage of infection with insects at the time of harvest was as follows :—

Mean percentage of infection

Insects	Mosaic-free	Mosaic-infected
Top shoot borer	12.2	17.2
Stem borer	6.9	7.6
Root borer	13.2	13.3
Termites	7.9	7.8

The difference between the means was statistically significant in the cases of top shoot borer (odds 180 : 1) and stem borer (odds 42 : 1) but not in root borer and termites. No damage was caused by fungal diseases or by animals. After removing cane to eliminate edge effects the plots were five by fifty yards and the yield of stripped cane in maunds was as follows :—

Weight in maunds of stripped Co. 213

Plot	Mosaic-free	Mosaic-infected	Plot	Mosaic-free	Mosaic-infected
1 2	45.06	36.71	20 19	44.55	37.55
4 3	42.21	36.45	21 22	41.23	40.88
5 6	40.88	37.46	24 23	46.24	40.11
8 7	44.35	39.35	25 26	44.82	38.77
9 10	42.72	41.03	28 27	44.31	39.53
12 11	48.06	39.90	29 30	44.56	40.34
13 14	45.94	36.95	32 31	45.57	36.54
16 15	40.39	34.88	33 34	45.15	34.47
17 18	42.74	39.79	36 35	40.30	32.97
Mean .	43.84	38.00			

The mean difference 5.84 maunds or 13.3 per cent. is significant.

Difference 5.84 maunds or 13.3 per cent. is significant.

Randomized samples from all plots were analysed and the details of the statistical significance calculated by Student's method

of the difference in yield between the series of healthy and mosaic plots are summarised below :—

Co. 213	Mean difference (MF—M)	Standard deviation	Mean difference	Odds
			standard deviation	
Weight of cane . . .	5.84	2.65	2.2	Very high.
Percentage juice to cane	.77	1.5	.63	70:1
Calculated juice per plot	4.30	2.1	2.05	Very high.
Brix . . . . .	.10	.78	.04	0
Sucrose . . . . .	.24	1.13	.21	4:1
Glucose . . . . .	.04	.17	.023	0
Purity . . . . .	.78	2.03	.38	14:1

The difference in weight of cane, percentage juice to cane, and calculated juice per plot were statistically significant. This season the differences both for top-shoot-borer and stem borer were statistically significant, so the difference due to borers has to be subtracted from 13.3 per cent. The loss in weight of cane bored by these two insects has been found by experience to be approximately 26 per cent. The loss due to both borers together is accordingly 4.96 per cent. in the mosaic-free and 6.45 per cent. in mosaic-infected plots. 43.84 maunds, the recorded mean weight of cane in the mosaic-free plots, represented 95.04 per cent. of the weight, if the cane had not been bored; similarly 38 maunds represented 93.55 per cent. in the mosaic-infected plots. If there had been no borer attack the means of the weight of the two sets of plots would have been 46.12 and 40.62 maunds respectively. The difference of 5.5 maunds represents 11.9 per cent. and is approximately the loss in weight due to mosaic disease. The quality of juice as measured by brix, glucose, sucrose and purity was, however, not affected.

An experiment to see the effect of the mosaic disease in reducing the tonnage of Co. 213 sugarcane in South Bihar under irrigation and in a type of soil different from that of Pusa was carried out at Patna Farm in collaboration with Bihar Department of Agriculture. Twenty plots, each 44 yards long and 5 yards wide were laid out in adjacent pairs as at Pusa. Mosaic affected canes for the test were obtained from Pusa where the setts were selected at the time of harvest from plants whose leaves showed the usual symptoms of the mosaic disease. The mosaic-free canes were

carefully selected from the crop grown on the Patna Farm from plants whose leaves had no mottling.

The incidence of the insect attack was small and very little damage was done to the crop. The crop was free from disease excepting smut which appeared in a few shoots in April, 1933. The canes were harvested on the 17th of March, 1934. Edge effect was eliminated by cutting off two yards of cane growing at the ends of the rows and five lines of cane at the sides of the two end plots, thus leaving plots 5×40 yards in extent. The weight of stripped cane from each plot is shown in the table below :—

Weight in Maunds of stripped cane

F	M	F	M	F	M	F	M
1	2	35.44	28.18	12	11	37.44	29.85
4	3	32.05	29.95	13	14	38.29	31.20
5	6	35.16	27.85	16	15	37.82	31.55
8	7	34.38	26.49	17	18	38.58	30.26
9	10	35.82	28.49	20	19	34.68	27.10
		35.99	29.09				

Mean Difference 6.90

The mean of the mosaic-free plots is 35.99 while that of the mosaic-infected is 29.09 maunds. The difference of 6.90 maunds or 19.17 per cent. is statistically significant.

Randomized samples from all plots were crushed and analysed. The statistical significance of the differences in the various factors are summarised below :—

Co. 213	Mean difference (MF—M)	Standard deviation	Ratio	Odds
Weight of cane . . .	6.9	1.7	1.0	Very great.
Percentage juice to cane	.16	1.5	.1	1.59 : 1
Calculated juice per plot	1.57	1.36	3.3	Very great.
Brix . . . . .	.09	.51	.18	2 : 1

Thus the differences in weight of cane and calculated weight of juice to cane are statistically significant.

An experiment to find out the effect on tonnage and juice of Co. 213 sugarcane by mosaic disease was carried out by the Plant

Pathologist, United Provinces, at the Research Farm, Cawnpore, at the suggestion of the Sugarcane Mycologist. Six plots, each 90' \times 22½' were laid out in adjacent pairs. Mosaic-infected canes for the test were obtained from Pusa and the mosaic-free canes from the Research Farm, Cawnpore. From the data kindly supplied by the Plant Pathologist, it is found that the mean of the mosaic-free plots is 49.74 while that of the mosaic-infected is 41.86 maunds. The difference 7.88 maunds or 15.9 per cent. was statistically significant.

A comparative statement showing the results of each of the three experiments is given below :—

Percentage loss due to mosaic

Place	In Tonnage	In calculated juice
Pusa	11.9	12.94
Patna	19.0	19.4
Cawnpore	15.9	17.08

It would appear from these results that the effect of mosaic in appreciably reducing the yield was marked and significant this year at various places and under different soil conditions. The reduction was more marked at Patna and Cawnpore Farms where the soil was irrigated than at Pusa where no irrigation was given.

III. CANE DISEASE

Red stripe disease.—The occurrence of this disease has been found on many varieties throughout India. The disease assumed minor importance and has not yet been recognised as a separate disease from top-rot into which the disease ultimately passes. In minor cases it occurred throughout Bihar in almost all varieties grown. Bengal and Assam Farms also had it in abundance. Isolations made from various localities agreed in their reactions and were found to be the strains of the organisms isolated last year. The biochemical reactions of these are distinct from those of *Phytomonas rubrilineans* Lee et al. and *Phyt. rubrisubalbicans* Christopher et al. The pathogenicity of these organisms has been established but it appeared that the virulence was not strong in many strains. It has been found to occur at the following places and in the under-mentioned varieties :—

Gurdaspur—Co. 223, 300, 312, 313, 318, J. 213 and S. 48.

Lyallpur—Co. 223, 270, 287 and 318. Jullunder—Co. 343 and P. O. J. 2878 and "Mogul". Karnal—Co. 313 and Co. 384.

Ferozepur—Co. 213, 223, 262, 404, 1712, 6308, B. S. F. 12 (17), B. 6308 and Desi Ponda.

Padegaon—Co. 316 and P. O. J. 2878. Partabgarh—Co. 213, 300, 301, 312. Shahjahanpur—Co. 285, 312, 313, 331, 510, P. O. J. 2878 and C. S. varieties.

Stinking rot.—This is a new disease of sugarcane found during the year to cause serious damage in some varieties. It was first observed at the Sugarcane Research Station, Mushari, in Co. 300 and in Co. 313. The symptoms were wilting and rotting of the plant from the top downwards; the whole stem became a mass of semi solid stinking pulp with a peculiar fermenting smell. The disease was found during the heavy monsoon months. The leaves were completely dried up in advanced cases. The leaves died as the nodes of origin disintegrated. The disease made a rapid progress from the inception to the end. Two bacterial cultures were isolated from the diseased tissues. Inoculations to prove the pathogenicity of these showed that while one was pathogenic the other was saprophytic, but the mixed culture of these bacteria made very rapid progress in causing the breakdown of the tissue and fermenting the cells with evolution of the typical smell. The infection took place during the monsoon and when the atmosphere was saturated with moisture for a length of time.

The biochemical reactions of the organisms were studied. Cultural characteristics pointed to the organisms being of the *pyocyaneus* group but the reactions differed markedly from *B. xanthochlorum* Schuster, *B. apilatum* Brown and Jamieson, *B. marginale* Brown, etc., which are pathogenic to potato, beans and other plants. The organisms were motile with single polar flagella and did not form spores or capsules. They were non-pathogenic to potato, tomato, eggplant, capsicum and tobacco plants. No leaf spots or rot developed in these plants; only local points of infection dried up and the plants remained healthy.

The probable point of entry of the organisms in the plants is supposed to be through top shoot borer holes, the "dead heart" forming a suitable ground for mass development. When the rot developed it killed the plant within a fortnight. Stray cases were observed at Pusa in Co. 313. The isolations made proved to be similar to those obtained from Mushari. The disease was also observed at Shahjahanpur in Co. 312 (G. C. Serial Nos. 67 and 49) and was quite conspicuous. Organisms with similar characteristics have been isolated from these specimens, but their pathogenicity has yet to be tested.

Ustilago scitaminea Syd. was recorded in the following varieties at Karnal (Punjab):—Co. K₂, K₃, K₇, 213, 290, 313, 317, 318, 319, 327, 331, 356, 369, 384, 385, 391, 396, 400, M. 49881, 54723, 57514, 58229, Katha, Dhau of Batala, Lalri and on C. S. 5 (213 × 244) and Co. 401 at Shahjahanpur.

Cercospora longipes Butl. was recorded on the following varieties in severe form at Karnal :—

Ck. 11, 12, Co. 285, 300, 320, 321, 325, 343, 345, 366, 368, 371 372, 374, 377, 379, 382, 390, 391, M. 44797, 49881, 54723 and 58224

Thielaviopsis ethacetica Went. was found in "Poovan" at Coimbatore, S. India. The symptoms of the disease were similar to those of wilt. The leaves dried up as in the case of drought from tips and the whole cane wilted. In early stages on cutting open the stem the core was found to be reddened, but on incubation it turned sooty black with macrospores of the *Thielaviopsis ethacetica*. At this stage the characteristic odour of pineapples was noticeable. A culture was obtained. The pathogenicity of the fungus was established and its morphology was studied. The perfect stage, *Ceratostomella paradoxa* (de Seynes) Dade appeared in the culture.

A new seedling disease was observed at Coimbatore. The seedlings were found to die in great numbers in pans where sugarcane seeds were planted. The yellowing of the leaves was first noticed and this was followed by wilting of the plants. On investigating the cause of this trouble the roots were found to be discoloured and brittle. In some infected cases the dark brown discolouration of the leaf sheath was prominent. The symptoms of the disease were like those of 'Foot rot' caused by *Helminthosporium sativum* P. K. and B. in wheat. A species of *Helminthosporium* was isolated from diseased seedlings. Infection experiments were carried out to prove its pathogenicity in Co. 414, 419, 420, B. 3412, M. 16 and Lalgira, it was found to infect both upper and under surfaces of leaves. The characteristic leaf spot developed in all the varieties. The inoculations made at the foot of the tillers from various varieties showed that the fungus was infective and parasitic only under excessive moisture conditions of the soil.

The study of the top-rot caused by *Fusarium moniliforme* Sheld. was continued, isolations made from various places have been tried for their virulence and pathogenicity. One strain isolated from Dacca differed in cultural characteristics from those of a strain isolated from Pusa.

Fusarium strains were isolated from cases of top-rot in jowar, but they failed to infect sugarcane and their virulence for jowar itself was limited. Maize also failed to take up the infection. *Fusarium* strains isolated from sugarcane were introduced into jowar and maize and it was found that they were not pathogenic for these crops.

In July 1933 the top-rot disease caused by *Fusarium moniliforme* was much in evidence in the farm on Co. 210, 213, 299 and

tonnage plots in mosaic experimental area. Experiments for controlling the disease by spraying colloidal sulphur were carried out. 100 diseased plants were marked and dusted with RV₃ Sulphur, 100 marked diseased plants left over to serve as control and 100 healthy marked plants were kept under observation. At the harvesting time following observations were made :—

	Healthy plants	Died attacked by white ants	Died-shoot borers	Total
Treated with RV ₃ S.	63	19	18	100
Control, diseased	69	15	16	100
Healthy	83	6	11	100

The results indicated that the plants recovered from the disease of their own accord and that dusting with RV₃ Sulphur had no beneficial effect in particular. The disease weakened the plants which fell an easy prey to white ants and shoot borers ; the loss thus engendered was nearly 17 per cent. in number of plants.

IV. PROGRAMME, 1934-35

1. Cultivation of mosaic virus in vitro and problems developing therefrom. 2. Study of physiological and histological changes in the sugarcane brought about by mosaic disease. 3. Effect of various physical and chemical factors on virulence of mosaic virus. 4. Tonnage experiment on effect of mosaic on Co. 213. 5. Varietal test experiment to see the natural spread and resistance in different varieties. 6. Masking and elimination of mosaic under natural conditions. 7. Investigations on red stripe and stinking rot diseases. 8. Physiological studies on *Cephalosporium sacchari* Butl., *Fusarium moniliforme* (5 strains), *Thielaviopsis ethacetica* Went. [= *Ceratostomella paradoxa* (de Seynes) Dade], *Colletotrichum falcatum* Went., *Ustilago scitaminea* Syd. and *Helminthosporium* sp. causing foot rot of seedlings.

V. ACKNOWLEDGMENTS

Thanks are due to Dr. S. S. Sokhey and Dr. Wagle, Director and Bacteriologist respectively of the Haffkine Institute, Bombay, for their keen interest and help in carrying out the serological reactions under their supervision.

VI. PUBLICATIONS

- I. Desai, S. V. Nature of viruses. (*Poona Agricultural College Magazine*, Vol. 25, No. 3, December, 1933).
 - II. McRae, W. & Subramaniam, L. Effect of mosaic disease on the tonnage and the juice of sugarcane in Pusa, Part IV. S. [*Ind. J. Agri. Sci.* Vol. IV, Pt. V, Oct. 1934, pages 787—796.]
 - III. Sarkar, B. N. & Dutt, K. M. . Effect of mosaic disease on the tonnage and the juice of sugarcane in Patna. [*Ind. J. Agri. Sci.*, Vol. IV, Pt. V, Oct. 1934, pages 796—802.]
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REPORT OF THE IMPERIAL ENTOMOLOGIST

(P. V. ISAAC, B.A., D.I.C., M.Sc.)

I. ADMINISTRATION

I held charge of the section throughout the year in addition to my own duties as Second Entomologist (Dipterist).

Rai Bahadur C. S. Misra, Assistant Entomologist, was on leave on average pay until 2nd July 1933 and again from 19th to 31st January 1934.

The second Assistant Entomologist's post sanctioned during the year 1932 has not yet been filled.

Mr. H. L. Bhatia, Assistant, left Pusa on 1st March 1934, to take up an officiating appointment in Class II for ten months under the Director, Imperial Institute of Veterinary Research, Muktesar, and remained away for the rest of the year.

II. TRAINING

Mr. Hira Nand Batra, B.Ag. Post-graduate student, was under training during the year.

Mr. E. J. Vevai, B.Ag. (Bombay), Post-graduate student, was admitted on 2nd November 1933 for training.

III. INSECT PESTS

SUGARCANE

Definite observations were made on the bionomics of *Scirpophaga nivella* Fb., the sugarcane Top-shoot borer. It was found that the borer hibernated in cane as larvæ till the third week in February. Pupation began in the last week of February. The first moth was noticed to emerge on the 28th February.

The following table gives the number of egg-masses laid on a sugarcane experimental plot of 2.5 acres.

Month	Number of egg masses	Area of plot
February 1934	Nil	Acres 2.5
March 1934	497	2.5
April 1934	205	2.5
May 1934	575	2.5
June 1934	74	2.5

Final examination of the crops of cane covering an area of 1.95 acres was made from 17th March to 11th May 1934 to determine the incidence of the major pests of sugarcane. The examination was facilitated as the sugarcane had to remain in the ground till the end of May as the cane factories in the neighbourhood had been severely damaged by the earthquake on the 15th January 1934. In all 16,469 canes were examined. It was found, that the percentage of healthy canes in both the crops where canes were grown without any irrigation varied from 21.10 per cent. to 45.41 per cent. The percentage of infestation by the Top-shoot borer, *Scirpophaga nivella* Fb. varied from 11.55 per cent. to 35.37 per cent. The percentage of the three stem-borers, *Chilo zonellus* Swinh., *Argyria sticticrasis* Hmp. and *Diatraea venosata* Wlk. together varied from 2.33 per cent. to 8.01 per cent. The percentage of damage by the root-borer, *Emmalocera depressella* Swinh. varied from 3.2 per cent. to 11.55 per cent. The percentage of infestation by Termites was low and varied from 1.48 per cent. to 7.82 per cent.

During April and May the number of adult *Pyrilla* spp. present on sugarcane planted in February was insignificant. By the middle of June the number of adults increased and oviposition on a large scale took place. In the beginning of August large numbers of eggs were laid and the parasitization of eggs varied from 52.5 per cent. to 68.7 per cent. By the end of September the parasitization reached as high as 94.9 per cent. Thereafter it declined, and eggs were laid mostly in sheathing leaves from October onwards. By the end of October considerable number of nymphs were parasitized by *Dryinus pyrrillæ* Kieff. and *Chlorodryinus pallidus* Perkins.

Of late, the yellowing disease of sugarcane leaves has attracted much attention in the sugarcane growing tracts of North Bihar. During the year under report, a large number of plants in the experimental plot were affected by this disease. Investigations have been begun to find out the causative agents of this disease.

Co-operation was given to the Mycological Section in the investigation of sugarcane mosaic disease. The tonnage experimental plot was under constant observation and efforts were made to keep the insect pests in check in the plot throughout the year. The egg-masses of the Top-shoot borer *Scirpophaga nivella* Fb. were collected and destroyed, and dead hearts and damaged shoots were removed.

At the time of harvest during the end of February and in the beginning of March the percentage of damage by *Scirpophaga nivella* Fb., by stem-borers, by the root-borer, *Emmalocera*

depressella Swinh. and by termites in the Tonnage experimental plot was found to be as detailed below :—

		<i>Scirpophaga nivella</i> Fb (Top-shoot borer)	Stem borers	<i>Emmalocera depressella</i> Swinh. (root borer)	Termites
		%	%	%	%
Co. 213	Mosaic-tree canes.	12.22	6.9	13.16	7.91
Co. 213	Mosaic infected canes	17.25	7.6	13.28	7.85

OTHER PESTS

Diacrisia obliqua Wlk. was very bad on *til* (*Sesamum indicum*) and potato plants in beds. *Prodenia litura* Fb. and *Plutella maculipennis* Curt. damaged early planted cauliflowers. *Ergolis merione* Cram. was exceptionally bad on castor leaves. *Dysdercus cingulatus* Fb. and *Oryzarcenus latus* Kby. were present in numbers on *bhindi* (*Hibiscus esculentus*). *Athalia proxima* Klug. appeared in large numbers on mustard, radish and other Cruciferae. *Maruca testulalis* Geyer and *Lamprosema indicata* Fb. were found in large numbers on *Urad* (*Phaseolus radiatus*) pods. *Prodenia litura* Fb., *Heliothis* (*Chloridea*) *obsoleta* Fb. and *Gallobellicus crassicornis* Dist. appeared in large numbers on tobacco seedlings. *Utteihsa pulchella* Linn. and *Etiella zinckenella* Tr. did much damage to sann-hemp pods. *Maruca testulalis* Geyer. did considerable damage to velvet beans. *Chilo oryzae*, *Nephotettix apicalis* Motsch. and *Nephotettix bipunctatus* Fb. appeared on rice. the two latter when it was in ears.

The worst attack during the year under report was that of *Agrotis ypsilon* Rott. on peas, gram, linseed, tobacco and cruciferous plants. Considerable damage was done particularly to peas, mustard and linseed crops. Hand picking trenching and poisoned baits were adopted. Flooding the affected area brought out the caterpillars to the surface and these were destroyed by birds that came down in swarms and quickly cleared the infested fields. The pea stem Agromyzid damaged a large number of plants in experimental plots. Light spraying with naphthaline emulsion had considerable effect on unrestricted oviposition. *Dichochrocis punctiferalis* Gn. damaged guava fruits both ripe and unripe. *Virachola isocrates* Fabr. also attacked guava fruits. *Amblyrrhinus poricollis* Boh. considerably damaged mango trees when these put forth new vegetative growths. *Nodostoma subcostata* Jac.

nibbled the skin of plantain fruits and made them unsightly. There was a mild attack of *Myzus persicæ* Sulz. on peach. Spraying with Nicotine sulphate was found to be effective. *Papilio demoleus* Linn. appeared on *Citrus* spp. Timely spraying with Lead arsenate and hand picking checked it completely. *Spodoptera mauritia* Boisd. was reported doing damage to paddy crop in Chakni, Champaran. Vulnerable points in its life-history and control measures were suggested. Rice stem-fly was reported to do considerable damage to paddy crop in Balasore and Sambalpur districts. Remedial measures were suggested.

Wire-worms (grubs of *Elateridæ*) damaged lentil crop in Bhopal. Control measures were suggested.

In the Insectary the life-histories of forty insects of different orders were studied partly or fully and both coloured and black and white illustrations were prepared to record the results obtained. The following are the more interesting ones :—

A female moth of *Dinara combusta* Wlk. was captured and it laid eggs on 1st August 1933. The larvæ were fed on maize leaves. They were fully grown by September 1933, when they pupated. The moths emerged in June 1934. Hibernation takes place in the pupal stage which is of nine and a half months duration.

One Asilid fly maggot *Philodicus* sp. was found in moist soil on October 20, 1933. The maggot pupated on 20th March 1934. The fly emerged on 15th April 1934.

During the year under report investigation on the probable transmission of the crinkly leaf disease and the yellow mosaic disease of tobacco by insect agency was carried on in the Insectary. No conclusive results could be obtained as the work was interrupted by the recent earthquake.

Experiments were started to try control measures against cockroaches. Various insecticides such as sodium flouride, borax, sodium fluosilicate, boric acid and copper carbonate are being tried to find out their relative efficacy to bring under effective check this obnoxious insect. Both stomach and contact poisons are being used. The results are not yet conclusive.

Investigation of Insect pests causing damage to the fruit trees in the Fruit Experimental Station, Quetta, and other fruit growing areas in Baluchistan was continued during the year under report. Numerous larvæ and pupæ of the codling moth *Carpocapsa pomonella* Linn. were seen causing damage to the apple trees at Quetta. At Fort Sandeman the pest was noticed infesting apples and pears. Grubs of *Aeolesthes sarta* Solsky, the "Quetta Borer," were collected from cherry and apple trees at Quetta. The presence of the grubs was indicated by the drying up of the terminal twigs and branches of the affected trees. Black Peach Aphid *Lachnus persicæ* Cholodk. was doing considerable damage to peach

trees in and around Quetta. At Fort Sandeman and Wiarat, apple foliage were severely infested by the larvæ of the Tortricid *Cacæcia pomivora* Meyr.

Surra disease broke out in the Government Dairy Farm, Karnal. A fieldman was sent on tour to collect biting flies associated with the disease and to locate their breeding grounds within the area of the Government farm. He prepared a map of the farm marking the actual and potential breeding grounds of *Tabanus* and other biting flies. Two kinds of Tabanid larvæ were collected from there and were reared in the Laboratory at Pusa and found to be examples of *Tabanus virgo* Wied. and *Tabanus tenens* Wlk.

The control of mosquitos on the Pusa Estate received constant attention. All breeding places were treated as far as possible. To guard against the breeding of *Stegomyia* the tree and bamboo holes near residential buildings were filled with earth.

A new fly-trap was experimented with and was found very effective to control house flies.

IV. BEES AND LAC

Apiculture.—Numerous inquiries were received and information and assistance was given as far as possible. There was an increasing demand for artificial comb foundations for *Apis indica* Linn. These were prepared in the laboratory on the comb foundation machine. Zinc queen excluders were supplied to several correspondents. Artificial standard hives prepared by a local carpenter were also supplied to some correspondents.

Lac.—The main crop of lac was adversely affected by the heat in June 1933. This did not revive well in the following October, with the result that the main crop in June 1934 was again a poor one.

V. INSECT SURVEY

Collections were sent out for identification to the following specialists and their help is gratefully acknowledged :—

Larvæ of nine different Curculionidæ to Forest Entomologist, Dehra Dun.

Cecidomyiidae to Director, Imperial Institute of Entomology, London.

Coccidæ to Mr. F. Laing, British Museum, London.

Thysanoptera to Dr. Ramakrishna Ayyar, Coimbatore, Madras.

Fruit pests collected from Quetta and other places in Baluchistan and other miscellaneous specimens to the Director, Imperial Bureau of Entomology, London.

Psyllidæ to Mr. D. L. Crawford, California.

Microlepidoptera to Imperial Institute of Entomology, London.

Isoptera to Imperial Institute of Entomology, London.

Lucanidae to Mr. G. J. Arrow, London.

Gryllidæ to Imperial Institute of Entomology, London.

Cerambycidæ to Forest Entomologist, Dehra Dun.

Aphididæ to Mr. F. Laing, British Museum, London.

Indian Insects were supplied to certain correspondents as listed below :—

Tabanidæ and *Oestridæ* to the Government Entomologist, Lyallpur, Punjab.

Specimens of *Schizodactylus monstruosus* Dr. including adults and nymphs of different stages to Mr. Kjell Ander, Zoological Institute, Lund University, Sweden.

Arctiidæ to Government Entomologist, Coimbatore, Madras.

Ichneumonidæ to Government Entomologist, Coimbatore, Madras.

Specimens of *Gastrophilus equi* Clark. to the Principal, Veterinary College, Madras.

Orthoptera to Government Entomologist, Lyallpur, Punjab.

Four specimens of *Asiathamanus cylindricus* Kirb. to the Director, Colombo Museum, Ceylon.

Calliphorinæ to W. S. Patton, Liverpool, London.

Collections of Indian insects were received from sixty-one correspondents. These were named and returned as far as possible.

VI. PROGRAMME OF WORK FOR 1934-35

MAJOR

This will follow generally on the lines of work of the current year and will include general investigations of crop pests and other injurious insects and especially of the pests of sugarcane, fruit trees and stored grains and domestic animals.

MINOR

Results in various lines of work require to be written up and published as far as possible. New insecticides and control methods will be tested as occasion arises. Systematic work will be carried on with our resources and the help of specialist correspondents. The Catalogue of Indian Insects will be proceeded with. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

VII. PUBLICATIONS

The following publications prepared by the staff have been issued during this year :—

- Bhatia, H. L. . . . A note on the Life-history of *Psilocephala sequa*, Wlk. (Fam. *Therevidæ*). *Ind. J. Agric. Sc.* **4**, 203.
- Fletcher, T. Bainbrigge . . Life-histories of Indian Microlepidoptera, Second series. *Cosmopterigidæ* to *Neopseustidæ*. *Sc. Mem.* **4**, *Imp. Coun. Agric. Res.*
- Isaac, P. V. . . . The life-history and seasonal abundance of the vesicating beetle *Pæderus fuscipes* Curt. *Ind. J. Agric. Sc.* **4**, 290.
- Isaac, P. V. . . . Papers on Indian Tabanidæ, X. The life-history of *Tabanus speciosus* Ric. *Ind. J. Vet. Sc. Anim. Husb.* **3**, 182.
- Isaac, P. V. and Misra, C. S. The Chief Insect pests of sugarcane and methods for their control. *Agric. and Live-stock in India*, **3**, 315.
- Narayanan, E. S. . . . Biological control of insect pests and the possibility of utilising *Trichogramma minutum* Riley in India for the control of sugarcane borers. *Agric. and Live-stock in India*, **3**, 459.
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REPORT OF THE BACTERIOLOGICAL SECTION

(N. V. JOSHI, B.A., M.Sc., L.Ag.)

I. ADMINISTRATION

I held charge of the section throughout the year.

I was on leave on average pay for 9 days from 2nd January 1934.

Mr. C. S. Rama Ayyar, Third Assistant Bacteriologist, was granted privilege leave for one month and twenty-eight days, combined with furlough on half average pay for two months and twelve days from 2nd June 1934.

II. TRAINING

There was no admission of post-graduate students during the year.

III. SOIL BACTERIOLOGY

Conservation of Nitrogen in soil.—The series of rotation experiments started four years ago to test the influence of leguminous crops on the conservation of soil nitrogen were continued. The figures for total nitrogen remaining in the soil at the end of the last harvest were, in the *kharif* (summer) series of plots lower than at the beginning of the experiments but in the *rabi* (winter) series plots, they were higher excepting one, the maize—barley rotation. Taking into consideration, however, the nitrogen removed by the crops, a gain in nitrogen is found in all the plots of both the series. The highest gain calculated in this way is 415·8 lbs. per acre in the *kharif* series with the mixed crop of maize and *urid* and 364 lbs. in the *rabi* series with the mixed crop *kerao* and barley.

The plots in both the series can be placed in two different orders according to (a) the observed gain in nitrogen in the soil and (b) the economic value of the crops produced during the last years under experiment. A careful statistical analysis is being made of the yields obtained as well as the nitrogen gained by the soil to ascertain which system of cropping is superior from both the points of view.

Nitrification.—The experiment started to find the seasonal effect on nitrifying flora in soil taken from field and in soil kept in the laboratory was continued. The changes in the seasonal

temperature appear to affect the nitrifying flora to a great extent and cause two periods of depression in May and November while the changes in moisture content cause comparatively minor variations in the nitrifying activity of the soil.

Bacteriological examination of soils from permanent manurial experimental plots.—The examination of samples of soil taken every three months from the permanent manurial experimental plots Nos. 3, 10, 12, 13 and 16 in the Punjab field was continued.

The nitrifying power of these samples was tested with *sarson* cake and ammonium sulphate as the material to be nitrified. The samples taken in June and December were comparatively richer in nitrifying organisms. The June samples nitrified both *sarson* cake and ammonium sulphate completely in 4 weeks and December samples took 8 weeks for complete nitrification. of ammonium sulphate but could nitrify only about 75 per cent. to 80 per cent. nitrogen of the *sarson* cake. During the same period the March and September samples were not able to nitrify more than 85 per cent. of the nitrogen contained in ammonium sulphate and 55 per cent. of the nitrogen contained in *sarson* cake. This indicates that there is either a difference in the numbers of the nitrifying organisms or a variation in the ratio of the nitrifiers to non-nitrifiers resulting in the varying nitrifying power of the soil in different seasons.

The comparison of the figures for the numbers of bacteria per gram and the percentage of the total nitrogen content of these soil samples with the figures of those taken in the previous year shows a difference in favour of the 1933 samples. It is not as yet known whether this is exceptional for the year or whether such annual increases and decreases in numbers of bacteria and in nitrogen content of the cultivated soils form a normal feature besides the regularly observed seasonal variation.

Decomposition of cyanamide in soil.—Last year it was reported that the chemical methods to be used in determining the course of decomposition of cyanamide were standardised. These were applied to Kalyanpur soil this year. Further work could not be undertaken after the earthquake owing to want of laboratory accommodation and insufficient pressure of water for filtration and distillation.

Bacteriological analysis of soils.—Bacteriological analysis of Pusa soil under irrigation and dry farming condition was continued. The number of bacteria and the total nitrogen were observed to be higher in irrigated plots than in unirrigated plots but as there is no marked difference in the ammonifying, nitrifying and nitrogen-fixing power between the soils from the irrigated and unirrigated plots since the experiment was started in 1934 it is

assumed that the changes in bacterial flora occurring after irrigation of soil are too slow to be discovered under Bihar conditions and it is proposed to discontinue the experiment.

Samples of the sand and silt thrown out by the recent earthquake were collected and a study of the bacteriological activity in these and the normal Pusa soil was made to get an idea of their fertility as compared with the normal Pusa soil. Slides put in the various silts and sands showed comparatively fewer organisms than in Pusa soil. The table below gives the average of pH indices and nitrogen content.

pH	Total nitrogen per cent.	Number of organisms per gram	N. nitrified Omelianaki's solution in 8 weeks
Silts . . . 8.4 . . .	.052	660,000 4,380,000	40 to 80 per cent.
Sands . . . 8.8 . . .	.032	484,000	30 per cent. up to nitrated stage.
Pusa . . . 8.1 . . .	.084	4,860,000	100 per cent.

The figures are the average of duplicate of four samples of each and show that the difference between the silts and the normal Pusa soil is not very great while the sands are poorer in nitrogen and nitrifying flora.

Green manures.—The field experiment started two years ago to compare the value of sann-hemp with *urid* and sann-hemp tops applied later in the season so as to secure the stems for getting fibre out of them was continued. The treatment of plots was retained the same as last year's, in order to bring out the fact that in spite of the original low fertility of the plots used for the treatment, where sann-hemp fibre is taken out and only the tops applied as manure, gives the highest net profit per acre of all the treatments.

The net profit reported after meeting cost of production for the years 1932-33 and 1933-34 are as under.

Treatment	1932-33	1933-34
	Average net profit per $\frac{1}{4}$ th acre	Net profit per $\frac{1}{4}$ th acre
T ₁ Wheat after maize	Rs. A. P. 22 14 9	Rs. A. P. 7 15 7
T ₂ Wheat manured with <i>urid</i>	14 11 2	8 14 8
T ₃ Wheat manured with sann-hemp	12 2 2	13 2 3
T ₄ Wheat manured with sann-hemp top and fibre extracted from the stems.	9 4 4	15 10 8

The average net profit reported is the average of four plots of 1/16th acre each. Last year it was reported that the plots used for the last treatment (T_4 in the table) were very low in fertility and had shown the least profits in the year 1931-32 in which year they were under the first treatment (T_1 wheat after maize). The fact that this year in spite of this initial low fertility, the net profits per acre in these plots are the highest of all the other treatments shows how great the improvement in the fertility of the soil is effected under the treatment of green manuring with sann-hemp tops and getting the fibre from the stems.

A similar experiment on plots of 1/5th acre and Latin square lay out with five treatments and five replications was carried out on the farm and the results reported as follows :—

Treatment.	Value of produce <i>minus</i> cost of cultivation	
	1931-32	1933-34
	Rs. A. P.	Rs. A. P.
T_1 Fallow wheat	29 2 4	24 13 9
T_2 Urid green manured wheat	22 6 7	15 10 11
T_3 Soybean green manured wheat	23 7 4	22 5 10
T_4 Sann-hemp green manured wheat	35 4 9	40 2 2
T_5 Sann-hemp tops buried, fibre extracted from stems and wheat.	30 8 3	48 13 7

The examination of the two years' results shows that the treatments T_4 and T_5 give best profits and that there is a very keen competition between the two treatments and the next year's results are awaited with interest. Under T_5 treatment the yield of fibre obtained from the stems more than compensates the labour involved in extracting it and the slightly lower yield of wheat obtained than in treatment T_4 where sann-hemp is buried.

The experiment on growing Mexican sunflower (*Tithonia diversiflora*) with onions and burying the Mexican sunflower as green manure was again carried out this year. The results show that control plots with onions alone yielded on an average 125.9 maunds per acre; the plots with onions and Mexican sunflower yielded 116.8 maunds of onions per acre and only 93 maunds of sunflower. This low yield of sunflower is due to the fact that sunflower could not be planted at the proper time in the middle of January owing to the disturbance caused by earthquake. Moreover sand and silt were thrown out in small fissures in these plots and irrigation

also could not be given as frequently as was described. The 93 maunds of Mexican sunflower obtained was buried in June 1934 in the same plots in which it was grown, and the yield of crops grown on the plots in the *kharif* and the *rabi* seasons of 1934 will be compared next year.

The yields of crops grown in plots of the previous experiments (1932-33) on growing Mexican sunflower with onions have shown increased yields of maize and wheat after burying the Mexican sunflower as green manure, but the question whether it is economic to do so has not yet been definitely established.

Manurial value of Katwa sewer.—*Katwa sewer* is an aquatic plant growing abundantly in the river beds. It has been found that it ferments very easily in the soil and supplies humus to soils and as such it is likely to prove useful for applying as manure in Indian soils which are known to be poor in organic matter. Some preliminary experiments were carried out to test its value in comparison with farm yard manure. The yield of maize (average of four plots) with farm yard manure was 8 maunds 26 seers per acre while with sewer it was 12 maunds 20 seers per acre showing an increase of 44.5 per cent. The economics of this manure will be worked out next year by statistical analysis.

Manuring experiment with potatoes.—In order to see what effect the application of different manures has on the keeping quality of potatoes it was necessary to grow the potatoes in manured plots. Comparison of yields of the plots under different manures for the last three seasons was found to be interesting showing that the *sarson* cake was the best manure for potatoes. The results were examined by the method of Fisher's analysis of variance, and were found to be highly significant. The important conclusions of the analysis are summarised in table below :—

Treatments	Mean yield in lb. per acre	Critical difference
T ₁ Mustard cake	7187	583.7 at 5 % level. 778.0 at 1 % level.
T ₂ Farm yard manure and superphosphate	5688	
T ₃ Farm yard manure	5241	
T ₄ Sodium nitrate	5621	
T ₅ Superphosphate	4388	
T ₆ Ammonium sulphate	4801	
T ₇ Potassium sulphate	3797	
T ₈ Control	3771	

$$T_1 > T_2 \ T_3 \ T_4 \ T_5 \ T_6 \ T_7 \ T_8$$

$$T_2 = T_4 > T_5 \ T_6 \ T_7 \ T_8$$

A paper is being written on the subject.

Dissociation of B. cereus.—Study of the dissociation forms of *B. cereus* which is frequently associated with the mosaic disease of tomatoes and other vegetables as well as of tobacco was continued. Another variant was found on plating of old broth cultures of this organism. The peculiarity of this variant is that it does not form spores and its colonies are free from the usual pellucid dots which is one of the chief characteristics of the normal cultures of *B. cereus*. No previous description of such a variant of *B. cereus* is found in the bacteriological literature studied and this is the first time that the existence of such a variant of *B. cereus* without the pellucid dots is recorded. This variant was not detected earlier because it could not be isolated from the agar cultures, which were studied and used for plating, since the cells of this variant of *B. cereus* occur in such small numbers in old agar cultures that they are crowded out by the colonies of the usual pellucid dot variant. In old broth cultures the percentage of cells of this variant is very high and hence when old broth cultures are plated out the colonies of this variant can be easily observed on the plates.

Previous workers have concluded that the pellucid dots observed in *B. cereus* cultures are the result of the association of a lytic principle with the bacterial cells, the dots being regarded by them as lysed spots. This conclusion of theirs is no doubt based on the consideration that they were not able to isolate a cultural variant of *B. cereus* without the pellucid dots and therefore they imagined that such a variant could not exist.

Work carried out in this section and reported last year had already shown that no lytic principle could be isolated from the cultures of *B. cereus* with pellucid dots, and hence these dots were then considered to be the result of the dissociation of the cultures into different types, although direct proof by the production of pellucid dots by growing the dissociated variants together was lacking at that time. After the isolation of the cultural variant without pellucid dots this year, it was possible to obtain direct evidence on this point. This new variant was grown in separate tubes in association with each of the other variants already isolated from the cultures of *B. cereus*. The associated growth of the new variant with (1) the Coccal rod variant and (2) the Coccus variant gave rise to the pellucid dots exactly similar to the normal *B. cereus* cultures. The associated growth with other variants produced no change.

It has been already observed that the cultures of *B. cereus* with pellucid dots when grown only from spores in successive transfers always dissociate into several variant types. The cells of these types are spread at random in the agar culture at first, but when certain particular variants come together and grow in

close proximity to each other, the pellucid dots having the appearance of lysed spots are formed owing to a difference in the transparency of their growths. The origin of the pellucid dots in the normal cultures of *B. cereus* is thus to be traced to its dissociation into cultural variants with growths of different transparency.

The filterable forms of *B. cereus* have also been observed and the conditions under which they remain stable, have been discovered and their stabilisation has been effected. The results of this study are being written up for publication.

IV. DAIRY BACTERIOLOGY

The average plate counts of the bacterial content of the Pusa milk supply are given below with those of the previous two years.

Months	Average counts per etc.		
	1931-32	1932-33	1933-34
July	3,833	5,225	13,200
August	4,092	7,857	6,843
September	4,753	10,575	8,611
October	2,333	13,760	5,249
November	3,490	7,713	6,563
December	3,400	4,098	10,077
January	8,825	6,508	5,336
February	4,000	3,617	4,625
March	9,750	5,071	5,882
April	8,617	3,717	7,050
May	5,871	5,127	10,629
June	7,192	8,283	7,290

In the first half year except in July the counts were lower than those of the preceding. In the latter half the counts are higher except in June. This is due to the damage caused by the earthquake in January to the milk collecting room provided with wire screens and the flies getting access to milk without proper control. In spite of this defect the counts were not very high even in April and May when the flies were numerous and could not be controlled by the fly traps.

The table below shows the number of *B. coli* present in the afternoon dairy milk supply at Pusa.

Month	Number of occasions when <i>B. coli</i> was observed			Total number of days in which determination was made
	1 c. c.	1/10 c. c.	1/100 c. c.	
July, 1933 . . .	..	12	6	13
August . . .	..	13	12	14
September . . .	..	7	<i>Nil</i>	9
October . . .	1	<i>Nil</i>	<i>Nil</i>	11
November . . .	4	2	<i>Nil</i>	12
December . . .	5	4	..	9
January, 1934 . .	11	3	..	11
February . . .	11	5	..	12
March . . .	3 out of 3	10	..	11
April . . .	..	12	5	13
May . . .	..	7	<i>Nil</i>	14
June . . .	..	9	4	12

Types of coli organisms.—250 cultures from colonies selected at random from the plates made from Pusa milk were examined. Of these 13 or about 5·2 per cent. did not ferment glucose and therefore do not belong to the coli group. 148 or 59·2 per cent. belonged to the *Aerogenes Cloacæ* group. The rest, i.e., 45·6 per cent. belonged to the coli group. In July organisms of *Aerogenes Cloacæ* group only were present. In August and September, the ratio of *Aerogenes Cloacæ* group to coli group was 70 : 30 and 58·5 : 41·5, respectively. The importance of the determination of this ratio will be apparent when it is realised that while the presence of *Aerogenes Cloacæ* group organisms indicates no faecal contamination, the presence of *B. coli* in large numbers indicates faecal contamination.

A series of fresh experiments on the use of Catadyn water was carried out to determine the germicidal value of the water passed

through catadyn pellets and its use in dairy practice to render dairy utensils free from contamination with *B. coli* and similar harmful organisms. The results have shown that catadyn water, if it is to prove effective, has to be passed through catadyn pellets immediately before use. It was found to retain its efficiency if stored in glass vessels for some hours (12 to 18 hours), but if stored in metal vessels it loses its efficiency much earlier than when stored in glass vessels. It cannot replace the washing of dairy utensils with soda as it cannot dissolve the thin layer of the milk-fat on the sides of the vessels. It is effective in killing the *B. coli* germs that remain attached to the vessels after cleaning with soda and soap. It can, therefore, replace steaming or chlorine disinfectant. The time of contact of catadyn water with glass bottles is required to be from 2 to 4 hours (according to the degree of contamination), in order to kill all coli organisms likely to be associated with such bottles. In the case of metal vessels 6 to 8 hours contact with catadyn water is found to be necessary. To be safe, the longer period of contact is to be preferred with both kinds of vessels. Whether it is possible to allow so much time, i.e., 6 to 8 hours for the dairy utensils to remain in contact with catadyn water will depend on the number of times of milking in the dairy and the kinds of vessels to be dealt with. If milking for 3 or 4 times is practised, as is done at Pusa two sets of milking cans will have to be provided if catadyn water is to be regularly used in practice in place of steam.

V. SILAGE

In previous years it has been found that some fodder plants such as berseem, kudzu vine and *dhub* grass (*Cynodon dactylon*) if ensiled by themselves do not yield a good silage; and that the addition of wheat or oat straw or molasses results in improving the product obtained after ensiling. A study of the changes in bacterial population of the different materials during the course of ensilage was made and it has been ascertained that the organisms of *Aerogenes Cloacæ* group are predominant in the early stages when berseem, *dhub* grass or kudzu vine are ensiled by themselves, *Streptococcus lactis* appearing only in later stages. When wheat straw or molasses are added, the predominant organism present from the start is *Streptococcus lactis*.

This difference in the kinds of organisms present in the initial stages of fermentation appears to be dependent on the kind of food available for the bacteria present in the ensiled materials and is of great importance in governing the kind of fermentation set up. This observation places at the disposal of the agriculturist a useful means of getting a good quality of silage from the materials which are available in abundance but do not yield a satisfactory product

when stored in the silage pit. What is required to be done is merely a suitable alteration of the composition of the material to be ensiled. This can be attained by the addition of surplus materials like wheat and oat straw or molasses which are at present running to waste in many sugar mills.

VI. POTATO STORAGE

Country potatoes grown after application of different manures were stored in March 1933 to see the effect of manuring on the keeping quality of potatoes. The potatoes were stored with and without charcoal for comparison. When taken out from storage in October 1933 almost all the tubers were found to be well preserved. There was a slight difference in favour of charcoal but as only 6 per cent. is the maximum damage in the number of tubers due to rotting in storage no distinction could be drawn between the effects of different manures.

Although well selected tubers from the manured plots were well preserved even without charcoal a mixed lot of tubers when stored without selection was damaged completely when no charcoal was used for storage while another lot which was also stored without selection but with charcoal had nearly 77 per cent. tubers well preserved.

As the preservation of the potato tubers in charcoal is partly meant for using them as seed, the yields of potatoes grown from tubers stored (a) with and (b) without charcoal were compared in 32 small plots measuring 22' x 9' for each kind of tubers. Out of these 32 pairs of plots, in 25 plots the yield was higher from tubers stored with charcoal than the corresponding plots sown with tubers stored without charcoal; and the average yield of the 32 plots was 14.9 per cent. higher from the tubers which were stored with charcoal than from the tubers stored without charcoal. It appears therefore that no harm is likely to result from storage of seed tubers in charcoal powder.

The reports on the storage of potatoes in charcoal according to our method from Nagpur and Cawnpore show that the potatoes used for storage at both the places could not be preserved. This effect may be due to the difference in handling which the potatoes received at the two places or the difference in variety. The potatoes stored at Pusa in this section were in almost all cases about 96 per cent. sound and had lost about 25 per cent. moisture only during storage showing that the method as carried out at Pusa eminently serves the purpose of storing the tubers till planting. A fresh experiment appears to be necessary to locate the cause of this observed difference in results of storage of potato tubers at Pusa and at other places and it has been arranged to have boxes of stored potato tubers exchanged between Nagpur and Pusa as also between Cawnpore and Pusa.

VII. PRESERVATION OF VEGETABLES

Studies on the preservation of vegetables on a domestic scale by encouraging the growth of lactic organism were continued. This year carrots were under observation. The pH of the carrots at the end of the fermentation process was found to be 3.45 and the total acidity on dry basis 20.34 per cent. The taste of the finished product was good and there was no bad smell. The organisms present were of the *Streptococcus lactis* type, showing that a normal lactic fermentation had occurred.

VIII. PLANT DISEASES

Damping of chilli seedlings.—The defoliation and death of the chilli seedlings in seed beds was found to be caused *B. vesicatorium* (Doidge). Spraying with 0.25 per cent. CuSO_4 or 0.25 per cent. Uspulun was found to bring the disease under control.

Yellowing of sugarcanes.—A number of clumps marked out as soon as "yellowing" was observed in the new area. The clumps were then divided into separate areas for treatment with different manures. The results are given in the table.

	Number of yellowing clumps treated	Number of yellowing clumps recovered	Per cent. recovery
Control	40	4	10.0
Ammonium nitrate	43	12	27.9
Potassium sulphate	42	22	52.4
Kamit	13	8	61.6

The results show that the percentage of recovery of the yellowing clumps is better with the potassium salts treatment than with ammonium sulphate.

IX. PROGRAMME OF WORK FOR 1934-35

Conservation of nitrogen in soil.—Conservation of nitrogen is one of the important problems in maintaining the fertility of Indian soils. A series of experiments of growing leguminous crops in mixtures or rotation were started four years back: one adapted to the *kharif* season and the other to the *rabi* season. These will be continued and the variations in total nitrogen in the soil and the economic returns of crop will be examined.

Green manuring.—The large-scale experiment will be continued of comparing *urid* and soybean and the application of sann-hemp tops late in the season after removing the stems for fibre, with the usual method of ploughing in sann-hemp.

The experiment with Mexican sunflower will be repeated and a large scale experiment tried on the farm.

Calcium cyanamide.—The decomposition products of calcium cyanamide in different soils which nitrify calcium cyanamide much later than in other soils will be studied.

Bacteriophagy.—Search for the bacteriophage from roots of cereals will be continued and they will be studied after their isolation to find what effect they have on the leguminous nodule organisms in soils.

Dairy bacteriology.—Quantitative study of bacteria present in general milk supply at Pusa at the time of distribution and in individual cows with a view to bacterial control of cleanliness in production of milk in the dairy will be continued. Study of starters producing flavour in butter will be continued. Observations on the kind of coli present in milk supply will be made.

Bacteriology of silage.—Preparation and study of silage from different fodders with the addition of wheat *bhusa* and molasses will be continued. Study of treatment of fodders with hydrochloric acid for their preservation as in A. I. V. process will be continued.

Other investigations.—Study of the preservation of fruits and vegetables by cold storage and the effect of spices in pickles in preventing spoilage will be carried on.

X. PUBLICATIONS

- Joshi, N. V. Kudzu Vine (*Pueraria thunbergiana*). (*Agr. Live-stock in India, November, 1933*).
- Joshi, N. V. and Ram Ayyar,
C. S. The Azotobacter plaque test of soil deficiency as applied to some Indian soils. (*Ind. Jour. of Agri. Science, February, 1934*).
- Vyas, N. D. Effect of Maize root washings on the fixation of Nitrogen. (*Ind. Jour. of Agri. Science, February, 1934*).

REPORT OF THE IMPERIAL DAIRY EXPERT

[ZAL R. KOTHAYALA, B.AG., B.SC. (AGRI.), N.D.D.]

I. INTRODUCTION

I held the post of the Imperial Dairy Expert throughout the year.

A new feature of this official year is the decommercialisation of the accounts of the Bangalore and Karnal Farms with effect from the 1st April, 1933, but the Wellington Farm to continue the same system of commercial accounts as before. The financial results of the Wellington Farm show a profit of Rs. 7,738 during 1933-34 as against a profit of Rs. 6,629 in 1932-33. The primary functions of the Bangalore Institute and Karnal Farm are now education and research, the dairy products obtained being disposed of mainly to the military customers. As regards Wellington, although it is looked upon at present as an institution for the supply of milk to troops, it is still used as an educational centre for imparting instructions to students in hill dairy farming.

Karnal.—Due to the unusually heavy rains during the year (47·23 inches as against 30·73 inches during the previous year) the whole of the cultivation work suffered. The outturn of the crops was poor and stagnant water in the grazing area brought about Surra and other cattle diseases. The diseases were brought under control by the prompt action taken by the Veterinary authorities at Muktesar. The breeding policy of breeding pure Haryana and Tharparkar cows by mating with selected bulls of the same breeds and of weaning the calves at birth continues.

Bangalore.—There was a drop in the sales of milk during the year due to the sale rates being higher than the prevailing rates locally. The outturn of fodder was also less than the previous year owing to scanty and untimely rainfall. The policy of breeding Scindi and Gir breeds in their pure state is being continued and records of tests of milk of individual cows are being maintained as on the Karnal Farm. A disease which was new to the farm broke out amongst the cattle in the form of Haemorrhagic Septicaemia but was brought under control with the assistance of the Mysore Veterinary Department. Our thanks are due to the staff of this department who are always ready to help the Institute with advice and treatment whenever any cattle diseases occur. The educational and research work continues at this farm. The farm as usual was visited by a number of visitors who appeared to evince a keen interest in the modern processes of manufacture of dairy products and cattle breeding.

Wellington.—As this farm is still looked upon as a commercial concern its financial accounts were prepared and showed a profit of Rs. 7,738 during the year. According to the Government orders cows in milk were sent to this farm from Bangalore for the supply of milk to the military and were returned to Bangalore when dry. The breeding experiments were stopped at this Institute according to Government orders.

II. TRAINING AND EDUCATIONAL WORK

The fifth batch of students for the Indian Dairy Diploma course was under training at Bangalore during the year. Eighteen regular students and one repeat course student sat for the final Indian Dairy Diploma examination held in the last week of November, 1933. Of these 15 students passed in the examination.

Another batch of 21 students was taken for the Indian Dairy Diploma course in October, 1933, and joined term at the Imperial Cattle Breeding Farm at Karnal and was under training during the rest of the year.

Three post-graduate students were admitted for training in January, 1934.

Eight short course students for varying period completed their training during the year. Of these two undertook short courses of a post-graduate character.

Out of the 15 British soldiers admitted for vocational training on 1st June, 1933, four left the course on 30th September, 1933, as they had to leave for England and the remainder completed the course on 30th November, 1933. A fresh batch of 15 British soldiers was taken for vocational training on 2nd February 1934 and was undergoing training during the rest of the year.

Along with the Indian Dairy Diploma examination held at Bangalore the final examination was also held at the Agricultural Institute at Allahabad. Six students passed out of eight who sat for the examination.

III. ADVISORY AND PROPAGANDA WORK

Advisory and propaganda work pertaining to dairying and animal husbandry forms an important part of the activities of the Imperial Dairy Expert and as a result of this work a great impetus is being given to the dairy industry of the country. During the year under report, necessary advice and assistance was rendered to about hundred official and private individuals and organizations in the matter of development of the industry either in the course of his tours or by correspondence.

IV. EXPERIMENTAL AND RESEARCH WORK

Bangalore.—The development of Scindi and Gir breeds of cattle by selective breeding was continued.

Milking of animals by weaning the calves was continued. Experimental feeding of dairy cows with rations containing a high protein contents was continued in co-ordination with the Physiological Chemist's Section with a view to find out result in the quantity and quality of milk, lactation period, body weight, heat period, subsequent calving, etc.

Hormone injection for the stimulation of fertility amongst cattle was experimented upon on all the three farms. No definite results have yet been obtained. Milk tests of individual cows of the different herds at Bangalore and Karnal were continued.

Statistical records on the yield of butter, cream, etc., were maintained.

A systematic investigation on the method of making Surti Cheese has been started and valuable data is being obtained with a view to standardising the process. The investigation has so far yielded very valuable results.

Wellington.—The following investigations undertaken during 1932-33 were terminated in December, 1933 :—

- (1) Effect of feeding bone meal on occurrence or re-occurrence of Oestrus.
- (2) Daily variations in fat per cent. of milk of individual cows during lactation.
- (3) Effect of feeding lucerne on milk yield.
- (4) Sex ratio of calving in relation to advancement of heat at the time of service.
- (5) Collection of statistics from old records pertaining to:—
 - (a) Mortality among calves in rearing them on the "weaning" system on a hill farm.
 - (b) Proportion of male or female calves born.
 - (c) Effect of heat on yield of milk.

Karnal.—(1) Breeding experiments on Hariana and Tharparkar breeds of cattle on the same lines as last year were continued.

(2) The weaning of calves at birth and their hand rearing was continued.

(3) A feeding experiment on 24 milch cows to find out the relative drying off effect of wheat *bhoosa* and rice straw was undertaken and is in progress.

(4) An experiment on the prenatal treatment of cows and heifers in calf was undertaken and is in progress.

(5) Weaned male calves used as stud bulls were found to be slow in service. In order therefore to see if bulls will improve in service if they are allowed to suck their mother an experiment is being made in this connection.

(6) Statistical information on the outturn percentages of cream, butter and *ghee* under farm conditions is being collected.

V. CO-OPERATION WITH OTHER SECTIONS AND DEPARTMENTS

This section fully co-operated with the Physiological Chemist's section in providing it with facilities required for its experimental work, in the form of cattle, feed, etc. Also, the help received from that section in conducting various experiments in the Dairy is much appreciated.

VI ADMINISTRATION OF FARMS

The following detailed reports from the Superintendents of farms are submitted. These reports have been commented on by me in the introduction to this report.

BANGALORE

During the year Mr. S. Cox was in charge of the Institute from 1st April 1933 to 4th April 1933 when he went on leave for 8 months from 5th April 1933 and Mr. A. Lamb officiated for him from 5th April 1933 to 3rd December 1933. Mr. S. Cox rejoined after the expiry of his leave on 4th December 1933 and continued to hold charge till the end of the year.

There was a fall in the outturn of green fodder from the Farm lands to the extent of 214,871 lbs. as compared with the year 1932-33 and by 284,202 lbs. as compared with the year 1931-32. The decrease in the outturn during the year was due to want of rains at the proper time. This naturally resulted in increased cost of

production. A comparative statement showing the outturn of fodder for the last 2 years is given below :—

Kind of fodder	Acre-age	1933-34		Cost per 100 lbs.	1932-33	
		Outturn in lbs.	Total cost		Outturn in lbs.	Cost per 100 lbs.
			Rs. A. P.	Rs. A. P.		Rs. A. P.
Green Jowari .	56.28	1,206,400	2,507 14 8	0 3 4	1,560,340	0 2 2
Lucerne .	.79	84,427	305 6 9	0 5 9	96,448	0 4 11
Guinea grass .	9.03	1,190,965	2,031 3 5	0 2 9	968,460	0 3 2
Rhodes grass .	.46	54,560	81 3 9	0 2 4	79,600	0 2 3
Total .	66.56	2,536,352	4,925 12 7	0 3 1	2,704,848	0 2 7
* Green Jowari	..	240,380	441 2 3	0 3 0	283,355	0 1 10
* Guinea grass	..	5,000	1 2 0	0 0 4	8,400	..
Total .	..	245,380	442 4 3	0 2 11	291,755	0 1 9
GRAND TOTAL	..	2,781,732	5,368 0 10	0 3 1	2,996,603	0 2 6

* Grown at Bommanpally.

There was a drop in the sales of both milk and butter as compared with the previous year due to the high prices of these products as compared with the local market rates. This resulted in the customers withdrawing their patronage. Further one British Infantry Regiment was using margarine as a substitute for butter on certain days in a month. For comparison the prices are given below :—

	Local Rates	Farm Rates
	Rs. A. P.	Rs. A. P.
Milk	0 1 9 per lb.	$\left\{ \begin{array}{l} 0 \ 3 \ 0 \\ \text{and} \\ 0 \ 2 \ 6 \end{array} \right\}$ Mainly at As. 3.
Butter	0 14 0 „	1 4 0
Cream	1 0 0	1 12 0

2. As according to the Government orders the accounts of this Institute have been decommercialised since 1st April 1933 no financial results have been worked out.

(1) *Expenditure*.—Comparative figures for three years are given below :—

1933-34			1932-33			1931-32		
Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.
1,15,493	6	5	1,29,193	0	6	1,36,709	7	10

The decrease in expenditure as compared with the previous two years is due to economy and the purchase of some grain and fodder, more especially *ragi* straw at a lower price and further to the reduction in the quantity of butter purchased owing to the fall in the sales of Dairy Produce.

(2) *Receipts*.—Comparative figures for three years are as follows :—

1933-34			1932-33			1931-32		
Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.
92,426	7	9	1,16,560	10	3	1,27,077	3	2

The decrease in the receipts during the year was due to the fall in the sales of Dairy Produce as mentioned in the foregoing.

(3) *Sale rates of Dairy Produce*.—The sale rates were as under for the past three years except for butter to civilians which was Re. 1-4-0 per lb. during 1931-32.

	Rs.	A.	P.
<i>Milk</i> —			
Officers, Civilians, Troops and Hospitals	0	3	0
Married families	0	2	6
Issues at the Dairy in customers own vessel	0	2	6
Bulk for 50 lbs. and above issues at the Dairy in customers own vessel	0	2	0
<i>Butter</i> —			
Officers, Civilians, Troops and married families	1	4	0
Civilians from 5th February 1933 up to 31st May 1934	1	8	0
<i>Cream</i> —			
To all	1	12	0
<i>Cheddar Cheese</i> —			
Whole cheese	1	4	0
On cut	1	8	0

(4) *Establishment*.—The expenditure for three years under this head was as follows :—

1933-34			1932-33			1931-32		
Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.
34,974	5	0	31,834	4	0	37,372	7	0

The increased expenditure in this year as compared with the previous year was due to the reduction in the percentage of cut

in salaries of the permanent Establishment and the accrual of periodical increments in the pay of establishments as also to the pay of the officiating Superintendent being higher than the permanent Superintendent while he was on leave during the year.

3. *Cultivation*.—The same policy was followed during the year as in previous years, i.e., to raise as much green crops on the lands as the irrigated water would allow. This comprises an area of about 9 acres of Guinea grass, $\frac{1}{2}$ an acre of Rhodes grass and $\frac{2}{3}$ acre of Lucerne. These crops give a continuous supply of green fodder all the year round and which is of considerable value to the herd.

The remaining cultivation area of 56 acres is used for monsoon crop, usually *jowari* and which is utilised largely for silage making.

Rotation of crops is not followed as a rule as plenty of farm-yard manure is available and also because the harvesting of *jowar* is usually too late to permit of a winter crop being sown. Experiments in this direction have met with little or no success.

The only fodder purchased every year is *ragi* straw, which is not grown on the farm. It could be grown but it will be at the sacrifice of *jowar* which gives much heavier crops.

4. *Cattle*.—The herds maintained consist of cross-bred cows (i.e., those sired by imported Ayrshire bulls), Scindies, Girs and Murrah buffaloes.

The feeding of the adult herd is based on the starch equivalent contained in the mixed concentrates which consist of Bran, Groundnutcake, Brewery grains and Gram Chuni in the proportion 3 : 3 : 2 : & 1. A pound of this mixture has a starch equivalent of .53 and the Albuminoid ratio works out at 1 : 4.7.

Based on a live weight of 700 lbs. and giving milk of 4.2 per cent. butter fat a cow gets .25 starch equivalent per pound of milk yielded *plus* $\frac{1}{2}$ pound of oilcake for maintenance. Roughages are fed on a basis of 18 lbs. dry matter fed as green fodder, silage or dry *ragi* straw in whatever proportions they are available.

The comparative overall averages of milk per day of all the animals in the adult herd were as follows :—

	1933-34	1932-33	1931-32
Cows (X Bred, Scindi and Gir) .	8.3 lbs.	9.6 lbs.	8.6 lbs.
Buffaloes	6.8 „	11.6 „	7.8 „

The less average for cows for the year under review was due to the decrease in the cross-bred animals which yield more milk than the indigenous breeds. Cross-breds are being eliminated to conform with the breeding policy followed on the farm, i.e., to improve Indian breeds. The fall in the average was also due to the outbreak of foot and mouth disease on two occasions and

Haemorrhagic Septicaemia resulting in the death of some heavy milking cows. The policy of sending cows in milk to Wellington Institute and taking them back when dry also affects the overall average.

The less average for buffaloes is the result of the animals growing older every year. They are being replaced gradually.

The following figures show the merit of the different classes of animals :—

	X Breds	Scindi	Gir	Bufs.
Average daily number in herd, milking.	56	41	5	5
Average daily number in herd, dry.	19	38	6	4
Average milk yield in lb. per animal which completed its yield during the year.	66·3980	62·2770	5·1624	5·5482
Average number of days in milk of the same animals.	250	231	217	320

As the breeding policy is to improve Indian breeds and to reduce the cross-bred herd gradually the Scindi and Gir cows are crossed only by selected bulls of their respective breeds. The $\frac{1}{2}$ and $\frac{1}{4}$ breds are served by Imported Bulls and those with more than $\frac{1}{4}$ imported blood by pure Scindi Bulls.

Of the 81 animals including Young Stock sold during the year the majority were of the cross-bred type.

The quantity of milk produced was cows 515,343 lb. and buffaloes 20,307 lb.

Young stock.—The number of farm-bred heifers taken on as adult stock during the year was as follows :—

12 Cross-bred ; 9 Scindies and 1 Buffalo.

Rearing of Calves.—The number of calves born during the year were from Scindies 56, from cross-breds 85, from Girs 10 and from Buffaloes 3. The male calves dropped by X bred cows were given away soon after birth and the number so disposed off was 38. Of the remainder 11 male and 36 female calves died. Calves of Indian breeds are permitted to suck their dams till the milk flows but the calves of cross-bred cows are weaned 4 days after birth. Calves of all primiparous Scindi and Gir are weaned at birth. All calves are hand reared commencing with a ration of new milk which is later on supplemented by separated milk and grain rations.

In order to control services of young stock they are brought to the Bangalore Farm when about two years old from the dry stock farm and crossed by selected bulls. They are returned to the dry stock farm when in calf.

Dry Stock.—This is sent to the dry stock Farm at Bommanpally where it is kept until a few weeks before their calving, when they are returned to Bangalore.

All these animals together with the young stock kept there are fed on concentrates and fodder the whole year round, as the grazing is very scanty even during the rains.

The dry stock farm is also used for inoculation purposes.

Diseases.—There was an outbreak of Foot and Mouth disease in May 1933 and 42 animals including calves were attacked but there was no casualty. Again there was an attack of Foot and Mouth disease in August 1933 on 196 animals including calves and one Ayrshire bull ("Royal Leader") resulting in the death of 5 young stock (all $\frac{1}{2}$ th bred of 1 to 6 weeks old) and the Ayrshire bull (died of after-effects of Foot and Mouth). No further cases occurred.

In October 1933 there was an outbreak of Haemorrhagic Septicaemia which affected 23 animals including good milking cows resulting in the death of 11 animals of which 9 were cows, 1 bull calf and 1 buffalo calf. Immediate action was taken to protect the herd from this disease and Mr. K. Ranganath Rao of the Civil Veterinary Department (Mysore Government) gave much assistance throughout the year and particularly in this connection. He inoculated 276 animals and protected the herd (269) with vaccine without cost to this Farm.

The deaths during the year were as follows :—

9 cows	.	.	.	.	.	} Haemorrhagic Septicaemia
1 cow male calf	.	.	.	.	.
1 buffalo calf	.	.	.	.	.
8 cows	.	.	.	.	.	} Johnes Disease.
2 cow female calves	.	.	.	.	.
1 cow	.	.	.	.	.	} After-effects of Foot and Mouth.
1 Ayrshire bull	.	.	.	.	.
5 cow young stock female	.	.	.	.	.	Foot and Mouth,
1 cow	.	.	.	.	.	} Pneumonia.
1 cow female calf	.	.	.	.	.
2 cows	.	.	.	.	.	Cyst in liver.
1 cow female calf	.	.	.	.	.	Black quarter.
1 Do.	.	.	.	.	.	Suspected Anthrax.
1 Do.	.	.	.	.	.	Snake bite.
1 Do.	.	.	.	.	.	Accident.
24 cow female calves	.	.	.	.	.	} Mostly young calves died from various causes mainly of diarrhoea and dysentery, etc.
10 cow male calves	.	.	.	.	.
1 buffalo female	.	.	.	.	.	Died suddenly.
2 Do.	.	.	.	.	.	Gastritis and Impaction.
1 buffalo male calf	.	.	.	.	.	Impaction.

Several cases of abortion occurred among the cows of this Institute.

WELLINGTON

Mr. H. C. Verma, I.D.D., was in charge of the Institute practically throughout the year except from 26th February to 31st March 1934 when Mr. M. C. Rangaswamy was in charge.

2. The working of the Institute resulted in a profit of Rs. 7,738 as against a profit of Rs. 6,629 in 1932-33 and a loss of Rs. 15,922 in 1931-32. It will be seen that the improvement in the financial position of the Institute was maintained.

The Institute continued to be treated as a "Depot" for the supply of Dairy produce to the Military. Cows in milk were supplied to Wellington according to the requirements of this Institute by the Imperial Dairy Institute, Bangalore, and were returned to Bangalore when dry.

The causes in brief leading to the profit during the year under review are explained below :—

- (a) Requirements of the Military were met in full from home produced milk thereby preventing the necessity of purchasing milk from outside.
- (b) The purchase prices of grain and fodder were comparatively lower than that of the preceding year. The purchase rate of butter was also favourable being less by an anna per pound from 1st October 1933.
- (c) Notwithstanding the considerable fall in the total receipts for the year as compared with those of the preceding year, there was an improvement in the position. This was mainly due to the economies effected all round.
- (d) The favourable low rates of grain and fodder purchased during the year and the reduction in the milk herd which was confined to the military requirements, also helped to reduce the expenditure under the heads: Feed of Dairy Cattle, Freight and other sundry expenses.

The following table shows the value of capital assets at the beginning and end of the year under review :—

Particulars	Value on 1st April 1933	Additions during the year	Total	Condemnations and transfers	Depreciation	Casualties	Value on 31st March 1934
Land	10,919	..	10,919	..	..	..	10,919
Buildings	85,975	..	85,975	..	1,216	..	84,759
Plant and machinery	7,270	..	7,270	115	1,355	..	5,800
Live-stock	1,040	130	1,170	20	40	60	1,050
Total	1,05,204	130	1,05,334	135	2,611	60	1,02,528

3. *Receipts*.—The comparative figures of receipts for the last three years are set out in the table below :—

Dairy produce	1933-34		1932-33		1931-32	
	lb.	Rs.	lb.	Rs.	lb.	Rs.
Sale of milk. . . .	1,19,691	22,451	1,34,966	26,060	2,32,282	45,661
Butter	15,915	18,507	17,706	22,138	19,567	24,472
Cream	529	927	430	753	310	543
Separated milk . . .	150	9	410	14	..	..
Butter milk . . .	100	2	153	2	..	..
Cheese . . . .	..	..	..	..	41	68
Total receipts for D. P.		41,896		48,967		70,744
Miscellaneous receipts .		2,040		2,247		3,684
Total receipts .		43,936		51,214		74,428

All the items of receipts except the sale of cream during 1933-34 show a reduction as compared with those of the preceding two years. The drop in sales was due to the discontinuance of the supply of milk to the Civil Hospital, Coonoor. Another factor which contributed to the fall in revenue was the grant of 10 per cent. discount on sales to certain Military Institutions during the year.

The increased figure under "Miscellaneous receipts" during the previous year was due to the sale of surplus stores.

On the whole the total receipts of the year indicate a drop of 14·2 per cent. and 40·9 per cent. over the two preceding years, respectively.

4. The following table shows the sale rates of dairy produce prevailing during the last three years :—

Particulars	1931-34 Rate per lb.
Milk—	
To Officers, troops, Regimental Institutes and Hospitals	Rs. A. P. 0 3 3
To Married families	0 2 6
Butter—	
To all	1 4 0
Cream—	
To all	1 12 0
Separated milk—	
To all	0 1 0

5. *Establishment*.—Comparative costs of establishment for the last three years are shown in the table below :—

Particulars	1933-34	1932-33	1931-32
Superintendent . . .	..	..	5,400
Supervisor in charge . .	1,540	1,515	..
Permanent staff . . .	4,034	3,461	5,093
Temporary staff . . .	5,351	5,511	11,421
Total .	10,925	10,487	21,914

There was a considerable decrease in the cost of establishment as compared with the year 1931-32. The reason for this decrease is due to the retrenchment of the post of Superintendent and some other establishment as a measure of economy.

The slight increase during the year under review as compared with the year 1932-33 was due to the reduction of emergency cut in pay from 10 per cent. to 5 per cent. and to increments in the pay of establishments

6. *Trade*—There was a decrease in the sales as compared with the two preceding years. This was due to the restriction of sales to the Military only. The restrictions for not supplying the produce to civilians and private institutions should be removed. It will be in the interests of the Institute.

7. The following table shows the quantities of butter purchased and that produced and the comparative prices per pound for the last 3 years :—

Years	Purchased quantity	Price	Home produced quantity	All-in-cost
		Rs. A. P.		Rs. A. P.
1933-34	9,947	0 13 0	530	3 15 2.76
	5,273	0 12 0		
1932-33 . . .	15,957	0 13 0	1,805	4 9 7.04
1931-32 . . .	18,719	0 13 7	536	7 9 0

Home produced butter.—The manufacture of Farm butter was reduced to a considerable extent during the year as the total production of milk was mostly limited to the sales, resulting in less quantity of surplus milk being available for conversion into butter.

This factor and the reduction in the purchase rate of butter contributed to the reduction in the cost price of butter.

8. *Cultivation.*—The table below gives the particulars of land in acres, owned and leased by this Institute during the year.

Land	Arable		Grazing	Forest for fuel	Buildings and roads	Total
	Perennials	Seasonal crops				
Owned	5.50	25.25	25.01	7.00	6.08	68.84
Leased . . . .	..	20.00	29.00	..	..	49.00
Total	5.50	45.25	54.01	7.00	6.08	117.84

The following table shows how the arable land was distributed for cultivation and the rotation that was followed :—

Kharif	Acres	Rabi	Acres
Green grass, Lucerne, Rhodes and Guinea grass.	4.50	Rhodes and guinea grass and also Berseem.	4.50
Potatoes	5.25	Potatoes	4.75
Jowar	21.25	Barley	9.50
Maize	12.75	Oats and Peas	1.50
Ragi	6.50	Oats	25.25
Gram	0.50	Wheat	5.25
Total	50.75	Total	50.75

During the year 40 acres of land were taken on lease from the Cantonment authorities to grow our own green fodder for cattle, as the growing of fodder proves cheaper than buying in the market.

Including the leased land of 49 acres from the Cantonment Board, Wellington, the farm area was increased to 117·84 acres. The purpose for which it was utilised is shown above. Out of the 49 acres of leased land, 20 acres were put down both for Rabi and Kharif crops. The crop grew fairly well, but the outturn of maize and oats was not satisfactory for want of rain in time. Cultivation of lucerno, Rhodes and Guinea grass was continued for ensuring a regular supply of green fodder for cattle throughout the year. During the Rabi Season Barley was also grown for the supply of green fodder to cattle. *Jowar* and maize were the principal Kharif crops grown for making silage. This was very helpful in supplying the cattle with succulent fodder during the winter months when green fodder and grazing are scanty.

The table given below shows the comparative yields of crops for the last 3 years :—

Crops	1933-34 lb.	1932-33 lb.	1931-32 lb.
Rhodes and green grass . .	1,37,270	1,38,555	1,77,115
Lucerne	5,001	15,435	..
Maize	91,500	1,08,990	1,18,210
Jawar	1,44,700	1,26,655	52,125
Sunflower . . . . .	..	2,400	..
Bajra . . . . .	..	19,900	12,070
Wheat	52,415	11,535	..
Oats	48,300	58,140	2,36,305
Ragi	56,650	1,700	32,435
Cabbage . . . . .	..	8,800	14,285
Mangolds	3,300	520	..
Barley	17,700	..	..
Berseem	3,510	..	..
Oats and Peas	6,150	..	..
Gram	4,400	..	..
Total available food for cattle	5,70,896	4,92,630	6,42,545
Potatoes (Cash crop) . .	58,500	23,324	38,090
Total . .	6,29,396	5,26,014	6,80,635

Jowar and maize are found to be most suitable Kharif crops both for green issues and silage and oats, wheat, oats and peas mixed during the Rabi season. These crops give large yields and are economical to grow. During the year green fodder was produced at 0-7-3 per hundred pounds as against the market rate of about twelve annas per hundred pounds.

As usual the crop of potatoes was very beneficial as a rotation as it helped in the elimination of weeds. The crop was tried both in Kharif and Rabi being a remunerative one. During the year an outturn of 5,850 pounds per acre was obtained at the production cost of Rs. 1-8-3 as against 13 annas per 100 pounds during 1932-33. The increased cost was due to the average outturn per acre being comparatively less owing to the failure of rains. The following table shows the comparative sale prices of potatoes for the last three years :—

		Rs. A. P.		
1933-34	. . . . .	2	2	5 per 100 pounds.
1932-33	. . . . .	2	9	5 „ „ „
1931-32	. . . . .	5	1	7 „ „ „

Cattle.—This farm according to the orders of Government is still considered as a Depot of the Bangalore Institute as it had no special herd of its own. Otherwise in working it is quite independent of the other. Having no cattle of its own, no breeding experiments were conducted.

The table given below compares :—

- (1) Milking average per diem per head of milking cow and
- (2) Overall average of the year under review with the figures for the preceding year.

	Milking average per diem per head of milking cow	Overall average
1933-34	17-50	16-10
1932-33	18-35	16-13

The decrease in the milking average per diem per head is attributed to the frequent changes in the herd of cattle with varying capacities of milk yield.

The comparative production cost per pound of milk for the last three years is given below :—

	Per pound.
	Rs. A. P.
1933-34	0 8 1-6
1932-33	0 2 9-9
1931-32	0 4 8-4

The production cost for the year has gone up due to the fall in the yield of milk and also to increase in the direct charges.

There was no outbreak of any contagious disease during the year. The general health of the herd was good throughout the year. There were a few cases of abortion amongst the cows and the casualties were mostly due to Haematuria.

Education and Research.—The investigations which were taken in hand as mentioned in the annual report for 1932-33 were continued and terminated in December 1933.

IMPERIAL CATTLE BREEDING FARM, KARNAL

The charge of the Farm was held by the following officers, during the year :—

Mr. M. C. Rangaswamy from 1st April 1933 to 24th April 1933.

Mr. Harnam Singh from 25th April 1933 to 11th December 1933.

Mr. A. Lamb from 12th December 1933 to 31st March 1934.

The market remained generally steady, except that it was slightly unfavourable in the case of Dairy produce. The climate was generally unfavourable due to heavy rains and floods in September-October. The expenditure and receipts for the last 3 years are :—

	1931-32	1932-33	1933-34
	Rs.	Rs.	Rs.
Expenditure	1,08,144	73,060	65,105
Receipts	60,113	48,921	43,336
Net cost	48,031	24,139	21,769

The financial position shows a slight improvement over the last year, which is partly due to less expenditure in supervision charges on account of Mr. Harnam Singh officiating for Mr. Lamb and partly to competition in renting Jodhawala plot on lease for Rs. 2,200 as compared with a smaller amount previously.

Due to the storms and heavy rains during September-October a large number of trees were uprooted and this also added to the Farm receipts. There was a net decrease in capital assets due to the writing off of annual depreciation. The percentage of decrease in the comparative figures of receipts given above works out to 19 per cent. from 1931-32 to 1932-33 and 11 per cent. from 1932-33 to 1933-34. The decrease is due to the damage done to crops by an exceptionally heavy monsoon.

The comparative figures of sale rates of Dairy produce given below show a decrease. Due to the abundance of rains, the milk and its products could be had cheaper in the market.

	1932-33	1933-34
	Rate per lb.	Rate per lb.
Fresh milk	Re. 0-0-6 to 0-1-3	Re. 0-0-5-85 to 0-0-9
Butter	Re. 1-0-0 to 1-4-0	Re. 1-0-0 to 1-4-0
Cream	Re. 0-12-0 to 0-14-0	Re. 0-12-0 to 1-0-0
Cream on butter outturn . . .	Re. 0-10-0 to 0-11-0	Re. 0-9-6 to 0-10-0
Ghee	Re. 0-6-1 to 0-9-0	Re. 0-6-0 to 0-9-0
Separated milk	Re. 0-0-3 to 0-0-6	Re. 0-0-3
Cheese	Re. 1-2-0 to 1-6-0	Re. 1-2-0

The following comparative figures of cost of Establishment will show that there was a decreased expenditure principally on account of Mr. Lamb being away on leave.

	1932-33	1933-34
	Rs. A. P.	Rs. A. P.
Pay of officer	9,840 0 0	3,258 11 0
<i>Pay of Establishment.</i>		
Pay of Assistant Superintendent, Indian Supervisor, Accountant, etc. . . .	12,174 4 0	15,857 1 0
Pay of permanent non-pensionable establishment	1,360 0 0	1,418 8 0
Pay of temporary establishment . . .	13,387 2 0	13,354 14 0
Leave salary	1,613 1 0	1,226 2 0
Total	38,374 7 0	35,115 4 0

The demand for milk and its products at Karnal is limited. The produce which could not find a sale as milk, cream and butter at the Government sanctioned rates, was converted into *ghee* and sold.

The comparative sales for the last six months of the year under report as compared with those of the corresponding period for last year are given below. The decrease in the sale of cream is due to

no cream having been sold on Butter Outturn as previously. This was turned into *ghee* and accounts for the increase in the sale of *ghee*.

	Milk	Butter	Separat- ed milk	Cream	Ghee	Cheese
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
From October 1932 to March 1933 . . .	748	1,569	38	5,423	17	—
From October 1933 to March 1934 . . .	2,993	2,238	..	445	1,489	30

CULTIVATION

Area.—After handing over 30 acres of land to Sugarcane Sub-Station and 143 acres to Botanical Sub-Station the Farm is left in charge of 1,981 acres. Out of this :—

52·5 acres are waste lands.

293·0 acres were on cash rent for grazing and raising agricultural crops.

209·0 acres were reserved for grazing.

257·0 acres were under Roads and Buildings.

118·0 acres were under Home cultivation.

1,046·0 acres were given on *Batai*.

ROTATION

Home cultivated area.

Half the area was under *Juar* and half remained fallow in Kharif

Half the area was under wheat and oats and the other half was under gram in Rabi.

In Batai 2, 3, 4 and 5

Half under *Juar* and half fallow in Kharif.

Half under wheat and half under gram in Rabi.

In Batai 6 and 7

Paddy in Kharif.

Wheat and gram in Rabi.

Kharif crop

Main Kharif crops are *Juar* and Paddy.

Juar green sown in 5 Home area was converted into silage. Total *Juar* obtained was 15,26,879 lb.

The monsoon of the year was abnormal and greatly affected both kharif and rabi crops.

The rainfall recorded was 5.65 inches during June ; 9.36 inches during July ; 6.30 inches during August.

The rainfall was quite normal until on the 19th and 20 September there was a heavy down pour of 16.73 inches, an unprecedented record for Karnal. As a consequence plots Nos. 6 and 7 (Paddy Area) were flooded and the standing paddy crop was immersed in water for a complete fortnight. The grain and straw approaching maturity were very adversely affected. The grain was totally unfit for seed purposes and the straw could not be sold as its quality had deteriorated.

Rabi Crop

The heavy rains in September and a few late showers in October delayed the rabi sowing. The land was too wet to allow of any ploughing being done and the seed had to be sown in a half prepared or wet soil. Consequently the germination was poor and the resulting yield was also poor.

In the home cultivated area 16 acres were under oats. The result of the Botanical Sub-Station's oats sown as against farm oats is given below :—

Botanical Sub-Station's oats	. . . . .	Yielded 21.4 maunds per acre.
Farm oats.	. . . . .	Yielded 20.7 maunds per acre.

Wheat 8A. Punjab and P. 114 were sown. Last year's results of these 2 varieties were very favourable owing to favourable weather conditions. The yield was :—

P. 114	. . . . .	14.4 maunds per acre.
8A. Punjab	. . . . .	14.9 " " "

Similarly T. 58 gram was tried against local gram. The yield was :—

T. 58	. . . . .	26.5 maunds per acre.
Local Gram	. . . . .	23.0 " " "

The Botanical Sub-Station's oats were completely free from smut while the crop raised from Farm seed was affected with smut; thus lowering the yield and the quality of the grain.

Wheat 8A. Punjab lodged badly and was also affected to a certain extent by rust and loose smut while P. 114 was slightly attacked by rust and was nearly free from smut.

1933-34

Crop	Yield outturn in Home Farm			Yield outturn in Batai, $\frac{1}{2}$ share.		
	Area acres	Total yield Mds.	Average yield per acre Mds.	Area acres	Total yield Mds.	Average yield per acre Mds.
Wheat . . .	41.04	622.30	15.1	387.99	1,958.34	5.0
Oats . . .	16.66	334.0	20.8	..	..	..
Gram . . .	60.84	1,389.11	22.7	573.68	3,489.28	6.1
Paddy . . .	..	..	..	495.3	2,646.0	5.3

In Batai 2, 3, 4, 5 Wheat and Gram were the 2 main crops.

In No. 6 and 7 after the harvesting of paddy, wheat and gram are sown if the weather conditions permit. There is no certainty of a winter crop even when sowing is permitted, the object being to stop the growth of winter weeds and other rank grasses in the paddy field by anything it may be possible to obtain and without any financial loss to the Farm. Wheat and gram were sown in these 2 plots.

Hay Making and Silage

Grass from No. 4, 8, 9 was turned into hay.

Total hay made was 24,518 lb. silage in addition to grazing.

Average yield per acre in Batai is low because the crops of wheat and gram in plots No. 6 and 7 are always sown late and the low yield of this area lowers the average.

During the year under review, the sowings were late, and the wheat was attacked by smut and rust. Paddy remained immersed in water on account of the floods, and this accounts for a low

average yield. The comparative yield of crops for the last 3 years, is shown below :—

	1931-32	1932-33	1933-34
	Mds.	Mds.	Mds.
<i>Grains.</i>			
Rice (Ziri)	4,879	3,250	2,646
Wheat	2,985	3,680	1,922
Oats . . . . .	..	..	55
Gram	4,022	5,731	3,481
Mustard . . . . .	..	40	..
Peas	124	..	..
	lb.	lb.	lb.
<i>Fodders.</i>			
Green Jowar	748,985	276,164	16,200*
Dry Jowar	116,174	..	39,770
Green Maize . . . . .	..	40,657	..
Dry Maize (Maize Kurby) .	..	7,180	..
Hay	76,138	118,476	227,332
Bhusa (Gram, Wheat and Oats)	628,604	698,694	652,909
Rice Straw	628,604	3,332 md.	2,625 md.
Charri silage	5,870,123	1,551,840 lb.	940,836 lb.
Grass silage . . . . .	..	168,388 ..	364,300 ..
Anjan Grass seed . . . . .	..	53 ..	..
Green Grass fed green . . .	..	14,378 ..	..
Poolas (Thatching grass) . .	..	80½ md.	..

* Major part sold standing.

The strength of the live-stock at the beginning and end of the year was as follows :—

	1-4-33	31-3-34
Cows	132	129
Buffaloes	12	15
Cow bulls	8	9
Buffalo bulls	2	2
Cow young stock female	108	115
Cow young stock male	53	51
Buffalo young stock female	7	9
Buffalo young stock male	3	5
Bullocks	26	29
Horse	1	1
Sheep—		
Ewes	32	66
Rams	4	4
Female lambs	66	52
Male lambs	2	5
Total	456	492

Increase in stock is due to the following births during the year:—

Cow calves	104
Buffalo calves	12
	116

Transfers from young stock to adults :—

Cow females young stock	15 to adult cows.
Buffalo females young stock	3 to adult buffaloes.
Cow male young stock	9 to bullocks.
Cow male young stock	1 to bulls.

Disposals—

(1) Cows	13	} Were sold away due to old age, poor records and incurable disease as Johnes disease, etc.
Buffaloes	Nil	
Bullocks	2	
(2) Buff. male	1	} Were sold to private parties.
Cow males	4	
(3) Cow calves female	23	} These were condemned some at birth and some at an early age due to the following causes—
Cow calves male	26	
Buffalo female calf	1	
Buffalo male	Nil	
		(a) Low Dam records;
		(b) Not conforming to the type ; (c) Colour ;
		(d) Underweight at birth ; (e) Physical deformations;

Overall average milk yield of different breeds on Farm

Year	Tharparkar lb.	Hariana lb.	Buffalo lb.
1931-32	7.8	7.6	10.4
1932-33	9.3	8.4	13.0
1933-34	9.4	8.6	11.8

A comparison in overall average shows only a slight increase in the cow herd over previous years. This is due to ill-health on account of severe outbreaks of Surra and Foot and Mouth diseases during the best part of the year (September, October, November and December).

As regards buffaloes the decrease is due to (i) outbreak of Surra, (ii) advanced age, (iii) no new heifers completing their lactations.

Breeding

The main object is to select and grade breeds of high milking strain on the Farm. As regards sheep they are made use of for manuring purposes as their feed costs practically very little to the Farm.

The following tables show the improvement done in breeding since 1923-24 to 1933-34 :—

	Tharparkar Herd		Hariana Herd	
	Purchased	Farm Bred	Purchased	Farm Bred
Average milk yield lb.	2,235.5	3,650.6	2,256.0	3,636.0
Average lactation period in days	239.9	307.0	251.0	317.0
Average days dry	147.2	88.9	151.0	62.0
Average overall	5.5	8.8	5.3	8.7

Average milk yield of animals which completed their lactation in 1933-34

	Average milk yield lb.	Average No. of days in milk	Average days dry
Tharparkar	3,973.5	304	106
Hariana	3,805.0	300	102
Buffaloes	6,212.0	348	131

Results of selected breeding from the comparison of overall average for 3 years and percentage of increase/decrease each year for all breeds.

	Tharparkar		Hariana		Buffaloes	
	Over-all average	Percent-age of increase	Over-all average	Percent-age of increase	Over-all average	Percent-age of increase
1931-32 . . .	7.8	26	7.6	35	10.4	22
1932-33 . . .	9.3	23	8.4	23	13.0	25
1933-34 . . .	9.4	1	8.6	2	11.8	9 De- crease.

Records of six best animals of each breed which completed their lactation during the year were as under—

Serial No.	Animal No.	Age	Milk yield	Days in milk	Remarks
		Y. M.	lb.		
			<i>Tharparkar</i>		
1	215	9 4	5,588	306	Farm bred.
2	216	10 1	5,903	433	Do.
3	240	9 3	5,785	451	Do.
4	301	7 10	7,224	439	Do.
5	306	7 6	5,846	375	Do.
6	323	8 0	5,709	308	Do.
			<i>Hariana</i>		
1	108	14 0	5,872	317	
2	142	13 6	6,028	359	
3	270	10 0	5,553	282	
4	276	8 10	5,189	349	Farm-bred.
5	349	7 2	5,187	307	Do.
6	427	5 2	5,148	441	Do.
			<i>Buffaloes</i>		
1	31	5 4	6,670	413	Farm-bred.
2	39	7 8	7,754	411	Do.
3	40	7 8	7,001	391	Do.
4	42	7 7	5,064	241	Do.
5	45	6 7	7,395	373	Do.
6	48	6 5	7,748	326	Do.

No production cost of milk has been worked out by the auditors. Its working out appears to be of little value on this Farm, as the milk here is a bye-product and not a commercial product. The animals are maintained to meet the requirements of research and experiments.

Young stock.—15 cow heifers and 3 buffalo heifers calved during the year.

Rearing of Calves.—The system of weaning calves at birth is followed as a rule except in cases where Farm-bred animals fail to give milk up to expectations as the progeny of high milking dams. Such unweaned calves are tied before their mother during their milking time and are pail fed. This system of unweaning has proved very effective in a majority of cases.

Calves up to the age of one month only get pure milk and after this age it is gradually substituted by separated milk and after 6 months of age they get only separated milk.

Mortality.—4 cow calves ; 3 buffalo calves ; 6 lambs.

Dry stock is kept mostly on grazing and on a maintenance mixture ration until 2 months before they are due to calve when they are separated from the other stock and special care is given to them.

Diseases.—The following deaths occurred during the year:—

Cows	4 (1 from Surra, 3 from old age and other natural causes).
Female young stock	6 (1 from snake bite, 2 black quarter, 3 from other causes).
Male young stock	4 (3 from Surra and 1 from other causes).
Bullocks	4 (2 from Surra, 1 from Johnes disease and 1 old age).
Sheep	10 (From Gid and old age).

There were severe outbreaks of Foot and Mouth and Surra diseases during the months of September, October and November. 72 animals were affected with Foot and Mouth diseases which lasted from 12th October 1933 to 7th December 1933. Milking stock, bulls and male youngstock were badly affected with Cattle Surra which prevailed from 22nd September 1933 to 16th November 1933. Up to the 3rd week of October the infection was in a mild form but afterwards it spread in all the herd and then the help of the Muktesar Research Institute and the Investigating Officer of the Veterinary Department, Punjab Government, was sought. The causes of these epidemics were the outbreaks of foot and mouth, Surra, rinderpest

and Haemorrhagic Septicaemia, in the neighbouring villages and the city. The infection therefore also reached the farm.

Serum simultaneous method of inoculation was carried out by the Muktesar Veterinary Research Department. 85 animals were inoculated (48 youngstock females, 26 youngstock males, 3 cows and 8 bullocks).

Experiments and Research

Tests to determine the butter fat and solids-not-fat quantities were conducted and are being continued for the combined herd of the three breeds on the Farm and also for individual animals of the different breeds under the following heads :—

(1) A combined herd test for the two breeds of cows separately and of buffaloes daily morning and evening.

(2) Individual animals of the two breeds for one complete lactation daily morning and evening.

(3) In making the above tests a few exceptions had to be made from the daily tests to alternate days so as to reduce the volume of work, as this was proving too much for the existing staff.

(4) The individual animals who had completed the period of one full lactation under the above test were brought under weekly composite test and for which morning and evening proportionate samples were collected daily separately, preserved and tested once a week.

The number of animals under the above tests at the beginning and close of the year is given below :—

Description of Tests	Tharparkar		Hariana		Buffaloes	
	31-4-33	31-3-34	1-4-34	31-3-34	1-4-33	31-3-34
Daily	40	18	33	15	3	1
Alternate days . . . . .	..	12	..	13	..	8
Weekly . . . . .	..	16	..	14	..	..

Total on 1st April 1933 76 animals.

Total on 31st March 1934 97 „

The above includes the combined herd tests for all the breeds.

The accompanying table would give an idea of the capacity for fat production of the three different breeds of animals during the year.

Breed.	Total No. of animals in milk	Total fat produced in the year in lb.	Average per head in lb.
Tharparkars . . .	18,387	10,491.5	.57
Harianas . . .	16,148	10,088.3	.62
Buffaloes . . .	3,291	3,872.7	1.17

The highest yield of fat was produced by cows in July 1933, and by buffaloes in March 1934.

The compilation work was greatly handicapped on account of the shortage of staff.

SCIENTIFIC REPORTS

OF THE

Imperial Institute of Agricultural Research, Pusa

*(Including the Reports of the Imperial Dairy Expert,
Physiological Chemist and Sugarcane Expert)*

1934-35



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Scientific Reports of the Imperial Institute of Agricultural Research, Pusa.

*(Including the Reports of the Imperial Dairy
Expert, Physiological Chemist and
Sugarcane Expert)*

1934-35

REPORT OF THE DIRECTOR

[F. J. F. SHAW, D. SC., (LOND.), A.R.C.S., F.L.S., I.A.S.
AND RAO BAHADUR B. VISWA NATH, F.I.C.]

I. GENERAL.

Transfer of the Imperial Institute of Agricultural Research from Pusa to Delhi.—During the year under review, the decision to move the Imperial Institute of Agricultural Research from Pusa to Delhi was taken. This was necessitated by the destruction of the Phipps laboratory and many other buildings at Pusa in the great earthquake of the 15th January 1934.

The site which was finally selected for locating the new Institute lies about three and a half miles to the west of the Viceroy's House, New Delhi. Part of the land is within the limits of the Imperial capital area and a part belongs to the villages of Shadipur, Todapur and Naraina. The new site contains about 476 acres of good agricultural land and about 300 acres of pasture and land for buildings. The area of agricultural land available at the new site being very much smaller than that at Pusa, the farm at Karnal—about seventy miles by rail and good road from Delhi—will form a substation of the Imperial Institute of Agricultural Research at Delhi.

The Director of the Institute and a part of his staff were transferred to Delhi in November 1934 and the Director's office has been temporarily located in the Old Secretariat buildings. Steps were immediately taken, in collaboration with the local officials, for the acquisition of such land at the site as was not already Government property and plans and estimates for the lay out of the estate and

for the construction of residential and non-residential buildings were prepared in consultation with the Central Public Works Department.

Progress with the project has been very rapid. By February 1935 the necessary approach roads were made. His Excellency the Viceroy and the Countess of Willingdon laid the foundation of the Library on the 19th February 1935. Farm buildings and quarters for the advance party for agricultural lay out were completed by May 1935. The agricultural staff, with implements, bullocks and steam ploughing tackle arrived at the site in May 1935 and commenced the difficult and arduous task of levelling and laying out the agricultural and botanical areas.

By the end of July 1935 the Farm buildings and most of the residential buildings were in an advanced stage of construction and a commencement was made on the library and the laboratories. The preliminaries relating to the supply of electricity, filtered and unfiltered water and the disposal of sewage and drainage were settled by September and the preparation of necessary plans and estimates for these items was commenced. It is expected that the construction of buildings will be completed by April 1936 and that the necessary fittings and equipment will be installed by September 1936. The actual transfer of staff and stores and livestock from Pusa will, it is hoped, be completed by September 1936.

II. RESEARCH AND INVESTIGATIONS

SOILS AND FERTILISERS

In view of the decision to shift the Institute from Pusa to Delhi next year, research work in all the Sections, except that of the Botanical Section which retains a Substation at Pusa, was confined to the completion of the work on hand or to bringing it to a stage at which it could be kept in abeyance. In the Agricultural Section the cropping scheme for *rabi* (winter) was materially altered by cutting down the area for seed multiplication and providing land to grow sugarcane as a revenue crop.

A series of experiments carried out with different soils and different nitrogenous materials has not afforded any evidence to confirm the recent claims by the workers of the Allahabad University that sunlight is largely, if not entirely, responsible for bringing about nitrification in the soil. Mr. Joshi and his co-worker have, on the other hand, found that direct exposure of soil to strong sunlight inhibits nitrification and reduces nitrates.

The estimation of nitrogen-fixing and carbondioxide evolution capacities of soils collected in different seasons from plots receiving differential manurial treatments has not revealed consistent and marked differences due to treatment or season.

In previous years it was stated from laboratory experiments that the yield of wheat after applying sann-hemp tops alone was equal to that when the whole of the sann-hemp plant was buried in the soil, and that the cultivator would get additional revenue of fibre from the stems. This has been confirmed in a field trial: the yield of fibre from the stems remaining after using tops as manure was 500 to 600 lb. per acre. The economics of the problem will be fully discussed in a report which will soon be ready for publication.

With a view to ascertain the possibilities of making the insoluble phosphate in the apatite called Khudada phosphate available to crops, two composts were prepared, viz. (1) apatite 100 lb. + sand 100 lb. + sulphur 25 lb. + charcoal 16 lb. + water 25 lb. (2) apatite 100 lb. + green berseem (clover) 100 lb. + sulphur 25 lb. The matured composts were tested on the field scale along with the raw phosphate in a finely ground form, and the yields of mustard obtained did not show that the preparation of either compost was worth while.

In experiments designed to elucidate the lime requirements of acid soils maximum crop yield was obtained from plots limed to pH 7 and the yields decreased with increasing applications of lime, except in the case of barley plants which yielded the maximum when liming was done at twice the amount required to bring the soil reaction to pH 7.

A study on dew as a factor in the moisture economy of the soil, and the contribution made to the growth of *rabi* (winter) crops was carried out both in the laboratory and in the pot-culture house, with tobacco seedlings which were neither exposed to rain nor were watered. Dew was the only source of moisture, and the seedlings lived throughout the season, passing through the usual vegetative and reproductive phases. Determination of moisture in soil at different times of the day indicated that, besides supplying three to four per cent of moisture in the surface layers, dew deposition takes place even in the lower layers of the soil down to a depth of one foot. It would appear that evaporation and absorption phases operate in the soil to an extent that the balance is enough to sustain the normal functions of the plant. At or about the hygroscopic stage, the soil loses appreciable amounts of water during day but during night more moisture is gained both by direct absorption and condensation in the interior of the soil. This increases with the depth of tillage.

Sann-hemp (*Crotalaria juncea*), cow pea (*Vigna catjang*), mung (*Phaseolus radiatus*), sweet-pea (*Lathyrus adoratus*) and *keras* (*Pisum arvense*) are under investigation to ascertain (1) whether bacteriophage occurs in all legumes and legume nodules, (2) if it occurs, whether it is the same or different in different types of

nodules, (3) if different, whether they form the basis for the classification of nodule bacteria, and (4) the relationship of the bacteriophage to the formation or otherwise of nodules. It is also being ascertained whether different forms of *Azotobacter* exist in soils, and, if so, whether they fix nitrogen in an equal or varying degree as compared to the large globule or oval forms of *Azotobacter* in Ashby's mannite solution.

Among other investigations bearing on the maintenance or improvement of the fertility of soils may be mentioned those intended to elucidate the optimum requirements of calcareous soils, as typified by the Pusa soil containing about 40 per cent of calcium carbonate, in nitrogenous, phosphatic and potassic fertilizers, the availability of superphosphate in relation to depth of placement, and the relationship between citric acid solubility of a phosphatic fertilizer and crop response.

CROPS

Wheat.—Large-scale tests with *Pusa 165* (*Federation X Pusa 4*) and *Pusa 120* (*Federation X Pusa 52*), in comparison with the standard Pusa and Punjab types, made simultaneously at Pusa, at Karnal, and at several farms in the Punjab and the United Provinces under various climatic and other conditions including canal-irrigated, well-irrigated and rain-fed lands, have established the outstanding success of *Pusa 165* which occupied the first three places 14 times out of 18 trials. In the United Provinces and the Eastern Punjab to which it appears to be particularly well suited *Pusa 165* invariably outyielded the best local varieties and the established Pusa types. Characterized as this hybrid is by good stand and comparative resistance to rusts, it is destined to play an important part in the agricultural economy of the wheat-growing tracts for which it is eminently suited. Two more hybrids with *Federation* parentage have, in preliminary tests, done so well for the third year that they have been selected for more extensive tests.

A scheme for the breeding of rust-resistant wheats was started in April 1935 at Simla in collaboration with the rust research investigation. The scheme is financed by the Imperial Council of Agricultural Research and during the few months of the year under review in which it has been in operation numerous crosses have been carried out.

Barley.—Some of the Pusa types of barley were again tried at Karnal in an yield trial against two best Lyallpur types, and the plump-grained Pusa Type 21 headed the yield table. This high yielder was, however, susceptible to white-ant attack in the seedling stage. From comparative chemical analyses of seedlings of the most susceptible and least susceptible types, it would appear that the relatively small amount of silica and the consequent softness

of the tissues might be rendering seedlings of Type 21 more liable to white-ant attack. Eight Pusa types of barley were sent to Rothamsted for preliminary malting tests, and the results are awaited.

Oats.—By crossing Pusa types of oats with *Abundance* and *Scotch Potato* varieties, a number of very promising hybrids have now been secured which will be subjected to yield tests. Among the new varieties imported this year from abroad are *Fulghum* from America and *Belar*, *Gidgee* and *Laggan* from Australia which show promise under Pusa conditions.

Paddy.—Preliminary yield trials carried out with early (autumn) and late (winter) paddies have resulted in favour of Pusa Types 124 and 18 in the first group and Pusa Type 31 in the second group. Among the 42 types of paddies isolated at Karnal from samples collected from the United Provinces and the Punjab, Types 125 and 130 are very promising. Both possess somewhat long and slender grains and stand out well in the field.

Pigeon-pea.—A yield trial with eleven types of Pusa pigeon-peas was conducted on the Pusa Farm and Types 64, 24 and 15 occupied the first three places, but the differences between their mean yields were not significant. Some hybrids combining wilt-resistance with erect habit have been fixed and their seed is being multiplied for yield tests. Experimental data are now available to substantiate the observation previously made that under ordinary conditions, the rotation of pigeon-pea with tobacco may considerably lessen damage due to *Fusarium* wilt in the former crop.

Gram.—Further yield trials have established that new Types 53, 55 and 58 are definitely high yielders and worthy of trial on outside farms with the old established Types, 3, 17 and 25.

Indian Hemp.—Three strains of Indian hemp (*ganja*) have finally been isolated. Types 1 and 2 are good for *ganja* production, the former giving high yields and the latter producing drug of a superior quality. Type 3, on the other hand, is a tall growing strain, not suitable for *ganja* production and is being maintained only because it throws out the least number of monoecious plants and may thus be of some use in sex-studies. In a smoking test held by the Superintendent of Excise, Patna, two veteran smokers spoke highly of the intoxicating effects of Pusa *ganja* as compared with the Bhagalpur product ordinarily available to them.

Tobacco.—Seed of Hybrid 142 (*Pusa Type 28 X Adcock*), *Adcock* and *Harrison's Special* was raised in large quantities for supply to the Provinces in connection with a co-operative scheme, financed by the Imperial Council of Agricultural Research, to determine what areas in India are suitable for the cultivation and curing of cigarette tobacco. A scheme, financed by the Imperial Council of Agricultural Research for the establishment at Guntur

of a tobacco Sub-station of the Imperial Institute of Agricultural Research, for experimental work on cigarette tobacco was sanctioned. Steps will be taken to acquire land and to commence work in 1936-37.

Potato.—A scheme, financed by the Imperial Council of Agricultural Research for the breeding of improved varieties of potato was started in April 1935 and work commenced at Pusa and on land at Simla adjacent to the rust research laboratory. A large collection of exotic species of *Solanum* from foreign countries was secured and at the time of writing is under growth. During the year 1935-36 co-operative potato trials are being carried out by Provincial Departments of Agriculture in order to ascertain the most suitable locality for a potato-breeding station in the hills.

Linseed.—In yield trials carried on for three successive years, standard Type 12 has consistently proved superior to all the hybrids except Hybrids 21 (T. 12 X T. 8) and 55 (T. 8 X T. 121) in one year when it was equal to these hybrids. During the year under report, H. 55 went down very much in yield as compared with the previous two years and its place was taken by H. 68 (T. 22 X T. 121) which appears to outyield the former in dry years and in tracts of low rainfall. The reports of yield trials conducted by some Provincial Departments of Agriculture also show H. 68 to be very promising. A study into the correlation between seed-size and oil-content indicates that the oil-content appears to increase with increasing lightness of seed-colour as well as with decrease in seed-size. This is contrary to general belief that the larger the seed the higher the oil-content, and the data available are being further analysed. Retting experiments carried out with Type 124 yielded fibre which, when sent to the Imperial Institute, London, for opinion, was adjudged as coarse but likely to find a good market in England. It is a matter of considerable interest that the ordinary linseed is capable of yielding marketable fibre.

Many other crops are also under investigation, for full details of which and of the numerous points of general interest connected with the work, reference should be made to the Report of the Botanical Section.

Sugarcane.—The sub-tropical types of sugarcane bred at Coimbatore, by their intrinsic agricultural characters, are invading parts of the country where sugarcane growing was formerly hardly considered a profitable proposition. For example, quite recently there has been a big expansion of sugarcane area in the tract commanded by the Nizamsagar canal in the Deccan Hyderabad, because of the introduction of Co. 213. Owing to the light nature of the soil cane growing used to be costly, as bamboo props had to be used to prevent lodging; Co. 213 through its excellent habit does not require such supports and besides grows well with less water. The

Coimbatore canes are receiving increased recognition in foreign countries as well: Co. 281 has proved resistant to "Streak" in South Africa and to "Pine Apple" disease in Porto Rico, Co. 290 is appreciated in Australia for its resistance to "gumming" disease, and Co. 213 has shown utility on low lands overrun with grass in Cuba and is a favourite in Brazil.

The more recent Coimbatore seedlings are steadily making headway in Northern India as further improvements over the Coimbatore types which are already popular. Co. 331, Co. 313 and Co. 299, the seed of which was distributed in large quantities during the year under report after extended trials on the Pusa Farm, have proved extremely successful on the growers' estates. The grower is benefited by their heavy tonnage and the factory by being provided with material for a longer working season, for Co. 299 and Co. 313 are early canes and Co. 331 is a late-season cane. Another new cane which is finding favour is Co. 312 which is distinctly drought resistant.

The work on thick or tropical canes which was started more recently has yielded types which have already earned good opinion. Of the thick seedlings under test on various experiment stations Co. 419 is easily the most outstanding for tropical conditions. It has shown better growth than the wonder cane of Java—P. O. J. 2878—in certain parts of tropical India. Very good preliminary reports have also been received about the performance of Co. 421 from more than one station in Northern India where it promises to be appreciated as a semi-irrigated cane.

At Pusa, an independent area of land measuring some 150 acres is mainly devoted to sugarcane experiments. The testing of new Coimbatore canes for field and other characteristics, tonnage trials with selected varieties, manurial experiments and general problems of cane cultivation form the basis of the work. As stated above, the trials made during the last few years have brought into general cultivation three canes (Co. 331, Co. 313 and Co. 299) which are equally welcome to the grower and the factory owner. Of the new importations, Co. 377, Co. 378, Co. 421, Co. 422 and Co. 423 appear to be promising from the habit of growth. A crop of Co. 210 sugarcane planted in March 1933, which stood in the field for the second year, was periodically analysed, and the results obtained indicate that, provided the weather conditions are favourable, as they were in the present case, there is practically no deterioration in the second year. The condition of the crop throughout the period was abnormally good; the average weight of a single cane was maintained all through; the purity of juice remained high and actually increased from November 1934 to the end of January 1935; in the rainy and humid period between the end of June to October 1934, the sucrose in juice was lower but it rose again to normal after October.

A simple process has been evolved in the Chemical Section for converting paddy husk into activated carbon which is useful in the manufacture of *gur*, white sugar and sugar candy by the open-pan system. Active carbon is imported from abroad at the cost of Rs. 1,000—1,500 per ton. The new process besides being cheaper, is so simple that, if necessary, the active carbon can be manufactured with the equipment available in a village by a person of average intelligence and at a tenth or even lower than the cost of the imported article. The new process carbon possesses the property of clarifying sugarcane juice to water-white colour and of absorbing other suspended and dissolved impurities. It absorbs organic acids. Not only the purity of juice is raised by three or four units but inversion in the boiling of the clarified juice is checked. *Gur* prepared by the active carbon process also possesses better keeping qualities than the best quality *gur* made by the usual process.

PLANT DISEASES

Research on mosaic and other diseases of sugarcane was continued in pursuance of a scheme financed by the Imperial Council of Agricultural Research since June 1932. The work recorded in previous years on the association of mosaic virus with an organism having a visible cyclostage could not find confirmation in 1935, possibly because the isolation work was started too late in the season. Inoculation experiments with Co. 213 and Co. 210 were also marked by the consistently low percentage of successful infections. A probable cause is an increased resistance of the varieties used both of which have been consistently rogued at Pusa. It has however been demonstrated that maize can be used as a test plant for sugarcane mosaic juice, giving consistently 50-80 per cent infection and providing a longer working season. The thermal death point of mosaic virus appears to lie between 40° and 45° C., in which it resembles that of tomato spotted wilt and of crinkle and mild mosaic of potato. Further work on stinking rot of sugarcane caused by an organism of the *Bacterium pyocyaneum* type has shown that two organisms are present, one giving whitish and the other bluish colonies on nutrient agar. A mixed culture of both was the most effective in bringing about the disease artificially. An investigation into the complaint that the sugar content of canes received in Bihar factories as apparently healthy, but showing reddening of the inner tissues when split longitudinally, was frequently reduced to one half or one third of that of the healthy canes, showed that (a) the primary trouble is the prevalence of borers, (b) that the fungal and bacterial infection is purely secondary, (c) that the loss of sugar due to micro-organisms is very localised, (d) and that the reduced sugar content of bored cane is principally due, not to loss of sugar, but to interference with the metabolism of the plant. Seed and soil treatments with an

organic mercury fungicide have proved successful in controlling the seedling disease caused by *Helminthosporium halodes* Drech.

Among the various treatments tested during the year for the control of bunt of wheat, soaking of seed in water either artificially heated or exposed to sun's rays proved very successful: the hot water treatment has the additional advantage of controlling loose smut as well. There is evidence that bunted infection is soil-borne as well as seed-borne and that a one-year rotation will not be sufficient. The burnt and brownish appearance of wheat grains known as "black point" was recorded for the first time at Pusa. On isolating the fungi responsible, 70 per cent of the seed was found to contain *Helminthosporium sativum*, the mycelium occurring within the seed-coat.

Detailed examination of samples of smutted oats collected from 24 areas situated in different wheat-growing provinces confirmed the previous observation that the predominant smut in Northern India is covered smut (*Ustilago kollerii* Wille) and not loose smut [*Ustilago avenae* (Pers.) Jansen.] The dry spray method of applying formalin to smutted oat seed was given an extended trial on nearly 100 acres; the resulting crop was practically free from smut, the infection being below 0.01 per cent.

Experiments carried out with various fungicides show that good control of foot-rot and root-rot of barley caused by *Helminthosporium sativum* can be obtained, by the use of mercury compounds. Such treatment, however, does not prevent secondary infection of the more mature plants by spores from neighbouring fields of wheat and barley or from certain wild grasses which can also act as host. Mercury compounds, formalin and solar heat treatment have all proved ineffective for controlling *Colletotrichum graminicolum* (Ces.) Wilson of sorghum.

Phenyl having been found a good substitute for Kerol for controlling foot-rot in *Piper betle* due to *Sclerotium rolfsii* Sacc. and *Rhizoctonia solani* Khun., pot experiments have been laid down to determine the lowest effective concentration of the more readily obtainable antiseptic.

Among other diseases under investigation may be mentioned the "black shank" and root-rot diseases of tobacco and a white rot disease of grape-vine caused by a new species of *Coniella*.

INSECT PESTS

As in previous years, sugarcane borers and other insect pests of sugarcane received considerable attention in the Entomological Section. The year's observations with borers show that the top-shoot borer (*Scirpophaga nivella*) is the most common pest; the root-borer (*Emmalocera depressella*), though attacking a fairly large percentage of canes, is responsible for proportionately very small

economic loss. Among the stem-borers *Argyria sticticraspis* predominates, *D. venosata* and *Chilo zonellus* being in very small number. It has also been noticed that the incidence of borers in sugarcane planted in October and in ratoon crops is much higher than in plantings done at the usual time in February. It appears that the October and ratoon crops, by affording food to borers during the period between the harvest of the old and the sprouting of the next crop, act as a source of infestation for February plantings. Work has now been started with a view to determining the comparative incidence of various pests on the most popular of Coimbatore seedling canes. Incidentally it will also be ascertained whether the treatment of setts with insecticides such as lead arsenate, copper sulphate, formalin and creosote, has any effect on the incidence of insect pests on the resulting crop. Among the parasites of cane pests recorded for the first time, a Chalcid wasp (*Trichogramma minutum*) parasitizing the eggs of the root-borer and a species of *Apanteles flavipus* parasitizing the stem-borer throughout the season deserve special mention : they will be studied in detail as they appear to have potentialities of proving very useful in the control of these pests. The morphology and bionomics of *Lepidosaphes*, a probable causative agent of the "yellowing disease" of sugarcane, were studied during the year.

Intensive research has been started to discover the probable insect vector or vectors of the leaf curl disease of tobacco which is on the increase in North Bihar and has been noticed to affect on the Pusa farm as many as 70 per cent. of plants. Of about 400 species of different insects collected from tobacco plants, ten were of the sucking type which is generally associated with virus diseases. Among the latter was a Capsid bug (*Engyrtatus tenuis*) with which transmission experiments have been undertaken.

The Cecidomyid fly mentioned in previous reports as doing heavy damage to linseed flowers has been identified to be a new species of *Dasyneura* and named as *D. lini* Barnes. In view of the proposed extension of linseed cultivation in India, it is feared that this pest is likely to become of major importance in future, and the differential susceptibility of various varieties under cultivation is being investigated.

A detailed study of the influence of different temperatures and humidities on the common grain weevil *Calandra oryzae* has been undertaken. It appears that the weevil if kept below a 60 per cent humidity does not lay eggs and even if a few eggs are laid, they do not hatch at all. The repellent action of some cheap country materials on the weevils is also being investigated.

The life-histories of about eighty insects were studied partly or fully, and some important pests of various crops occurring on the farm were successfully controlled by spraying.

THE SPREAD OF IMPROVED VARIETIES OF CROPS

The Botanical Section and its Substation at Karnal, and the Agricultural Section at Pusa distributed to Provincial Departments of Agriculture and to private growers the following quantities of seed of improved varieties :—44,054 lb. of wheat, 4,795 lb. of barley, 5,125 lb. of oats, 733 lb. of paddy, 10,119 lb. of gram, 2,052 lb. of pigeon-pea, 618 lb. of linseed, 164 lb. of hemp, 18 lb. of tobacco, 219,765 lb. of sugarcane setts and 1,451 lb. of maize and miscellaneous. The distribution of seed from Pusa was comparatively on a restricted scale than in the previous year and many indents could not be met in full, as the area under *rabi* crops was reduced to grow sugarcane for revenue purposes. The Sugarcane Station at Coimbatore supplied preserved sugarcane seeds of crosses of Co. 349 with Co. 312 and Co. 313 and about 5,000 seedlings of the same crosses to the Sugarcane Research Station at Shahjahanpore. An equal number of seedlings of Co. 213 crossed with Co. 285 and Co. 244 was sent to the Sugarcane Substation at Karnal. In addition, about 200 packets of seed canes containing over 60 varieties were distributed to 90 centres in India, and 27 packets were sent to Natal, Durban, Gold Coast, Kumasi, Formosa, United States of America and Iran.

AGRICULTURAL MACHINERY

The new model 18/30 H. P. Marshall Crude-oil tractor, obtained in exchange of the old 15/30 H. P. model, had a full year's trial and the total expenses for almost 500 working hours worked out at Rs. 1-7-3 per hour. It ploughed 1·12 acres per hour, as compared with 0·66 acre with the Lanz Bulldog 15/30 H. P. semi-Diesel tractor, and 0·90 acre with the Vickers 23/40 H. P. kerosene-oil tractor the respective cost per acre being Rs. 1-4-9, Rs. 2-1-4 and Rs. 6-14-9. In other agricultural operations such as harrow-ploughing, disc-harrowing, grubbing and rolling the Marshall tractor was equally economical. The 9/18 H. P. Farmall row-crop tractor, purchased last year, was used with cultivating attachment in the sugarcane crop and proved very satisfactory. Out of eight tyres and eight tubes originally fitted on four carts specially designed for the Dunlop pneumatic equipment two tyres and three tubes have called for replacement. The axles and hubs are not yet showing any sign of wear and tear.

CATTLE

A severe attack of foot-and-mouth disease, after an interval of eight years, overcame the Pusa pedigree herd of Sahiwal cattle and disturbed its metabolic and productive equilibrium with the result that the percentage of cows in milk was reduced to 60 from 66 of the previous year. Despite the intervention of foot-and-mouth disease, the remarkable improvement brought about by the new system of feeding and handling introduced about four years ago will be apparent from the fact that the percentage of cows in milk

stood at only 50·2 in 1931-32, and that the average herd yield per cow per day during the year under report was 19·1 lb. as against 18·7 lb. in the previous year and 13·6 lb. in 1931-32. Eight cows yielded over 8,000 lb. each in a lactation period of ten months, Laruli in her second calving heading the list with an yield of 8,823 lb. One heifer recorded an yield of 6,045 lb. closely followed by five others who all were above the 5,000 lb. limit. With a view to finding out the normal growth standard of the Sahiwal breed, data are being collected of weight and body measurements of every animal in the herd and young stock from birth. These data are expected to show how the stock could be raised most economically with reasonable rapidity, so that inherited growth potentialities may be realised to the fullest extent while they are young. The Chemical Section has isolated a flavour organism which produces butter of quality comparable with that produced with cultures of Nos. 27 and 29 of Hammer.

Karnal.—The results so far achieved with Tharparkar and Haryana types of cows are that the over-all (including dry period) average yield during the year under report worked out for farm-bred Thar-Parkars at 9·1 lb. and for Haryanas at 8·8 lb. as compared with 5·6 lb. yielded by both breeds when the foundation stock was purchased in 1923.

Bangalore.—The two indigenous breeds of cattle dealt with at this Farm are the Sindhi and the Gir (from Kathiawar). The over-all average (including dry period) of all cows on the farm which include some Ayrshire-Sindhi crosses rose to 9·0 lb. from 8·3 lb. in the previous year. At the milk depot at Wellington, to which cows in milk are supplied from Bangalore as required and returned to Bangalore when dry, the milking average per diem per head increased from 17·50 lb. in 1933-34 to 18·65 lb. With the decommercialisation of the farm, more attention is now being paid to the development of scientific and research activities. Among the investigations undertaken are those relating to (a) standardisation of the method of making Surti cheese, (b) the comparative efficiency of different methods of sterilizing dairy utensils and milk bottles and (c) the keeping quality of milk under different conditions and in vessels of different kinds (e.g. earthenware, glassware, enamelware, porcelain, etc.).

ANIMAL NUTRITION

Another year's work by the Physiological Chemist on the influence of high and normal protein feeding on milk production has shown that the consumption of roughage by the group of cattle on the high protein ration is more, which is reflected in increased live-weight. The milk yield for both groups is more or less identical, but the quality is richer in the case of the high protein group. The higher fat content in milk may be due to the higher quantity of fat ingested through the feed and not its higher protein.

The investigation into the comparative values of the mineral composition of grasses grown on selected typical soils in various parts of India has revealed distinct differences traceable to the nature of the soil. For example, the higher lime content of the Pusa soil is reflected in the grass grown therein. Each species of grass has also been found to show a tendency towards a mineral make-up peculiar to itself, *Cynodon dactylon* invariably showing a considerable excess of lime over phosphoric acid and *Pennisetum cenchroides* giving the reverse indication. The excess of phosphoric acid over lime is an unusual phenomenon observed only in two other cases, viz., Guinea-grass and sorghum grown at Bangalore. As previously reported, the mineral contents vary with the stage of maturity, the dead ripe stage producing very poor quality : it has since been ascertained that nitrogen and potash are more influenced by maturity than phosphoric acid and that the effect on lime and magnesia is the least. Each tribe of grass has also been observed to have a decided characteristic in having a high or low sulphate content. For example, the *Chloridae* contain the maximum amount of sulphate, while the *Andropogonae*, the *Panicae*, etc., contain much less.

The influence of progressive ripening of some fodders on the mineral nutrition of cattle is also under study. It has been noticed that early cut fodders produce markedly large volumes of urine which may be definitely attributed to the high amount of alkalis present therein, while some of the later cut fodders are distinctly acidic. The animal experiences difficulty in retaining minerals when the urine becomes acid.

Experiments are in progress to determine the highest phosphoric acid level that a grown up animal is capable of retaining and the effect of supplementing a ration with calcium sulphate. In addition, various physiological studies are in hand, for which reference should be made to the Report of the Physiological Chemist.

Feeding experiments have been commenced at Pusa with Sahiwal bullocks and cows to ascertain the digestibility values of feeds and fodders used, and the suitability and adequacy or otherwise of the ration fed to milch cows.

III. GENERAL ADMINISTRATION

Charge—The headquarters of Dr. F. J. F. Shaw, who held the post of Director, throughout the year, were transferred to Delhi with effect from the 5th November 1934.

The post of Joint Director was held by Mr. Wynne Sayer till the 12th June 1935 when he proceeded on leave for three months and eighteen days ; Rao Bahadur B. Viswa Nath officiated as Joint Director during the rest of the year under report.

Staff.—The posts of Imperial Agricultural Chemist, Imperial Entomologist and Imperial Mycologist were filled substantively

during the year by the recruitment through the Public Services Commission, of Rao Bahadur B. Viswa Nath, Dr. Hem Singh Pruthi and Mr. L. D. Galloway who assumed charge on the 22nd August, the 5th September and the 17th December, 1934, respectively. Rao Bahadur Viswa Nath also took over charge of the Bacteriological Section on the 1st November 1934 when that Section ceased to be an independent unit and became part of the Chemical Section. Until the arrival of the permanent Heads of Sections, Mr. P. V. Isaac officiated as Imperial Entomologist, and Mr. J. N. Mukerji, Mr. N. V. Joshi and Dr. M. Mitra, all Class II officers, held charge of the Chemical, Bacteriological and Mycological Sections respectively.

Owing to absences on leave, etc., the following changes in the charge of Sections were made:—

Agricultural Section.—Mr. Arjan Singh from the 13th June 1935, vice Mr. Wynne Sayer on leave.

Animal Nutrition Section.—Mr. A. V. Iyer from the 15th March 1935, vice Dr. F. J. Warth on leave preparatory to retirement.

Sugarcane Station.—Mr. N. L. Dutt for 14 days during July 1934, vice Rao Bahadur Venkatraman on leave.

EXTENSIONS

A Scheme for research on genetics of sugarcane and two other schemes, one for breeding potatoes for Northern India, and another for breeding rust-resistant wheats with the collaboration of Prof. K. C. Mehta of Agra College, all financed by the Imperial Council of Agricultural Research, came into operation in May 1934 and April 1935, respectively. The scheme for research into mosaic and other diseases of sugarcane, which was sanctioned in the first instance for a period of three years from 1st June 1932, has been extended by two years, and the life of the Botanical and Sugarcane Substations at Karnal has also been extended for another period of five years, on the understanding that the Botanical Substation will be transferred to the present site of the Botanical Section at Pusa as soon as the Institute itself is moved to Delhi.

Training.—There were 32 candidates for admission to the post-graduate courses beginning in November 1934, of whom 17 were recommended by Provincial authorities for nomination of students. Thirteen applicants were selected for admission: three in Botany, five in Agricultural Chemistry, of whom one left to proceed to England for specializing in animal nutrition, one in Entomology, one in Mycology, and three in General Agriculture. During the year under report, 10 post-graduates completed the two-year course at Pusa: five in Botany, one in Chemistry, one in Entomology and three in Sugarcane Breeding and Cultivation. The one-year course in farm organization, farm management and general farm engineering was completed by one student.

The fifteen-month post-graduate course in Animal husbandry, animal nutrition and dairying was completed by three students in April 1935. Of the two admitted in the new session beginning on 2nd January 1935, one soon left for Scotland for higher studies.

The class of 21 Indian Dairy Diploma students started in November 1933, which was depleted by the defection of one student, was restored to its original strength by the admission of one repeat course student on 1st June 1935. As the year under report was the intervening year no fresh admissions were made. Of the five students considered fit for award of the Diploma, after an examination held at the Allahabad Agricultural Institute, one was a repeat course student from the Bangalore Institute.

A number of students and post-graduate workers were also admitted for periods of work or training in various Sections of the Institute. A group of 15 British soldiers and another of 12 completed at the Bangalore Dairy Farm a six-month vocational course in practical dairying in July 1934 and January 1935, respectively. A third group of 13 admitted in April 1935 was under training at the close of the year. A special course in the flue-curing of tobacco lasting for two months was organized at Pusa, and, although there were a number of applicants, for want of accommodation, only ten students could be admitted to it.

Library.—Publications received in exchange numbered 1,147 while 382 were purchased. Of the 2,022 books, etc., issued on loan, 407 were to scientific workers in the provinces and universities.

Hospital.—There were 370 (new) and 4,882 (old and new) in-patients and 9,138 (new) and 24,232 (old and new) out-patients in 1934, and 411 operations were performed. The health of the residents of the Estate was, on the whole, satisfactory.

IV. ACCOUNTS

The total expenditure for the Institute and its out-stations during the financial year ending the 31st March 1935 amounted to *Rs. 9,68,471 as against Rs. 8,89,676 for the previous year.

Name of establishment	Expenditure. Rs.
General expenditure of the Institute, including the office of the Director, Power and Gas Plants, the Medical and Estate Establishments	2,27,452
Agricultural Section	1,51,525
Botanical Section	42,414
Chemical Section	78,009
Mycological Section	28,655
Entomological Section	59,251
Imperial Dairy Expert	29,857
Bangalore Dairy	1,18,678
Wellington Dairy	39,806
Karnal Cattle Breeding Farm	63,051
Physiological Chemist, Bangalore	49,318
Sugarcane Station, Coimbatore	80,455
	<hr/>
	9,68,471

The cost of the Botanical and Sugarcane Substations at Karnal and the schemes for research on mosaic and other diseases of sugarcane and on genetics of sugarcane amounting to Rs. 22,720, Rs. 9,140, Rs. 17,142 and Rs. 6,001, respectively, was met from the funds of the Imperial Council of Agricultural Research.

The receipts of the Institute and its out-stations amounted to Rs.* 2,02,106 as shown below :—

	Sale of dairy produce and livestock	Sale of farm produce	Fees from students	Miscella- neous receipts	Total
	Rs.	Rs.	Rs.	Rs.	Rs.
Pusa Institute . .	14,246	12,540	5,425	7,299	39,510
Bengalore Dairy . .	68,388	139	..	7,556	76,083
Wellington Dairy . .	40,817	..	..	1,986	42,803
Karnal Farm . .	13,000	19,000	..	3,030	35,030
Coimbatore Sugarcane Station.	..	..	..	8,680	8,680
	..	..	..	..	2,02,106

* Provisional figure.

REPORT OF THE IMPERIAL AGRICULTURIST

(ARJUN SINGH, L. AG.)

(1) AGRICULTURAL SECTION, PUSA

I. CHARGE

Mr. Wynne Sayer held charge of the office of the Imperial Agriculturist till the 12th June 1935, when he left on three months and eighteen days' leave after handing it over to Mr. Arjun Singh, Assistant Agriculturist.

Messrs. L. S. Joseph and P. V. Krishna Iyer held the posts of Cattle Superintendent and Statistician, respectively, throughout the year.

Mr. Arjun Singh, Assistant Agriculturist, was on leave on average pay for sixteen days from the 12th to 27th August 1934.

At the end of the year the following staff were transferred to Delhi as members of the Layout Party :

Mr. Lachman Das Ahuja, Graduate fieldman.

Mr. G. M. Sharma, Graduate fieldman.

Wali Mohamad, Head Jamadar.

Galli Thakur, Acting Fitter and Latheman.

Mushtaq Ahmad, Engine Driver.

Ramlal, Engine Driver.

Ram Uchit, Acting Engine Driver.

Jethua, Fireman.

Ramkhelawan, Fireman.

Bulbul, Jamadar.

Mr. J. N. Bhowmick, Fieldman, was transferred to the Agricultural Sub-station, Karnal.

II. TRAINING OF POST-GRADUATE STUDENTS

Messrs. Khushi Mohamad, B.Sc. (Agri.) and Harbans Singh, B. Sc. (Agri.), Sugarcane Research students, completed their training in October, 1934. Mr. R. K. Tandon, M.Sc., B.Sc. (Agri.), received training in farm organization and general agriculture for one year.

Three students, Messrs. N. K. Jadhav, C. Ekambaram and W. D. E. Perera, from the Animal Husbandry and Dairy Section, finished their training on the 31st March 1935.

Three Agricultural Graduates, Messrs. Anand Mohan Sinha, Prabhunath Prasad and Sukhsagar Lal Gupta were taken in for

post-graduate training in farm organisation and general agriculture from November 1934.

III. SEASON AND CROPS

The total rainfall during the year from the 1st June 1934 to the 31st May 1935 amounted to 41·33 inches against 51·70 inches in the corresponding period of the previous year. At the break of monsoon at its normal time (13th June), the sowing of all the *kharif* crops was successfully completed before the end of the month. Rainfall in the month of July was fairly heavy, and flood in the river at the end of this month destroyed 25 acres of green maize in the *dhab* area. The sluice gate at the main drain outlet being shut, accumulation of heavy rain water flooded 60 acres of *kharif* crop in the Brickfield. Deficient rain in the month of September gave an opportunity for early preparation for *rabi* cultivation. 2·78 inches of rain on the 15th October brought the temperature down and was more than sufficient for the sowing of *rabi* crops.

In view of the shifting of the Institute to Delhi, cropping scheme for *rabi* was materially altered, and the area for seed multiplication was considerably cut down to provide land for revenue crop (sugarcane). 237 acres were thus reserved and left fallow for planting sugarcane. An agreement has been executed by the Samastipur Central Sugar Co., Ltd., to purchase sugarcane grown on 311 acres (plant and ratoon) on the Pusa Farm during the sugar season 1935-36. The yield is estimated to be between 1,50,000—2,00,000 maunds.

The yields of principal crops grown on the Farm are given below :

Crop	Variety	Area in acres	Yield in maunds*	
			Total	Average per acre
Maize—corn . . . . .	..	71·58	857·95	11·99
Maize—green fodder . . . . .	..	209·00	21,508·70	102·91
Cowpeas . . . . .	..	4·49	29·38	6·54
Meth . . . . .	..	4·33	36·92	8·53
Soybean . . . . .	..	12·54	150·10	11·97
Green pulses—fodder . . . . .	..	39·00	4,054·62	103·97
Arhar	T. 15	22·00	318·21	14·46
Do.	T. 24	9·00	135·20	15·02
Do.	T. 51	9·10	94·53	10·39
Do.	T. 80	4·40	41·20	9·36
Do.	Other varieties	1·81	26·13	14·41
Barley	T. 21	13·27	226·95	17·10
Gram	Miscellaneous varieties	4·68	54·53	11·65
Oats	B S. I	152·65	2,560·79	16·78

*1 maund = 82·28 lb.

Crop	Variety	Area in acres	Yield in maunds*	
			Total	Average per acre
Oats	B. S. II	2.00	24.22	12.11
Do.	H. C.	3.00	22.97	7.66
Do.	H. J.	6.00	65.97	11.00
Wheat	Pusa 12	6.13	53.40	8.71
Do.	Pusa 52	12.58	101.30	8.05
Peas	P. F. 1	4.17	36.25	8.69
Do.	P. F. 2 . . . .	.17	2.14	12.59
Do.	P. F. 3 . . . .	.17	2.25	13.23
Do.	P. F. 4	1.10	16.46	14.96
Do.	P. F. 5 . . . .	.25	4.85	19.40
Do.	P. F. 6 . . . .	.22	2.25	10.23
Do.	P. F. 7 . . . .	.22	2.10	9.50
Do.	P. F. 8 . . . .	.22	2.56	11.64
Do.	T. 14-1	2.75	56.39	20.51
Do.	Other varieties. . . .	.66	5.45	8.25
Berseem-green fodder	..	108.55	31,057.90	286.12
Sugarcane (Gonhri) .	Miscellaneous varieties.	11.51	8,015.00	696.35
Sugarcane (New Area)	Miscellaneous varieties.	28.02	16,195.66	578.00

* 1 maund=82.28 lb.

IV. SEED SUPPLY

The great demand for seed of the improved varieties of crops could not be met in full as the area under *rabi* crops was reduced to grow sugarcane for revenue purposes.

The following seeds were supplied :—

Variety	Quantity
	lb.
Wheat P. 111	185.13
„ P. 12	41.14
„ P 52	185.13
Oats H. J.	164.56
Soybean	10.28
Maize No. 1	468.19
„ No. 2	4.11
„ No. 3	82.28
Arhar T. 51	164.56
„ T. 80	452.51
„ T. 24	593.68
Sugarcane Co. 299	1,40,318.20
„ Co. 331	77,801.40
„ Co. 313	1,645.70

V. EXPERIMENTAL WORK

The following experiments were conducted by the Agricultural Section during the year under report :

1. MANURIAL EXPERIMENTS

(a) Permanent manurial and rotation experiments, Punjab field, Blocks C and D.

(b) New manurial and rotation experiments in Randomised Blocks conducted on the lines of the above experiments, Punjab field, Block A.

(c) Green manuring experiment with sannhemp, *guar* (*Cyamopsis psoralioides*), *meth* (*Phaseolus aconitifolius*) soybean, cowpea and velvet-bean on wheat, Punjab field, Block B.

(d) Manurial experiment with rape-cake and superphosphate on sugarcane : different doses of nitrogen with a constant amount of phosphoric acid (P_2O_5), Gohnri field.

(e) Manurial experiment with superphosphate and rapeseed cake on sugarcane : different doses of phosphoric acid (P_2O_5) with a constant amount of nitrogen, Gohnri field.

(f) Green manuring experiment with berseem on sugarcane, New Area, Dholi Block

(g) Effect of silt and farmyard manure on sugarcane yield, New Area, Dholi Block.

2. VARIETAL YIELD TRIALS

(a) Maize for fodder, Punjab field, Block D.

(b) Maize for corn, Punjab field, Block A.

(c) Soybean for fodder, Punjab field, Block B.

(d) Soybean for seed, Punjab Field, Block D.

(e) Gram, Punjab field, Block B.

(f) Field-pea, Punjab field, Block B.

(g) Pea, Punjab field, Block B.

(h) Sugarcane, Co. 210, Co. 213, Co. 313 and Co. 331, Gohnri field.

(i) Sugarcane, Co. 213 and Co. 331, Gohnri field.

(j) Sugarcane, Co. 210 and Co. 213, New Area, Dholi Block.

3. MISCELLANEOUS EXPERIMENTS

(1) Experiments to see the effect of speed of tractor-drawn implements on soil tilth and crop yield, Brickfield No. 2.

(b) Spacing experiment with maize for fodder, Punjab field, Block D.

(c) Spacing experiment with maize for corn, Punjab field, Block D.

(d) Experiments on the spacing of sugarcane and arrangement of setts at planting, New Area, Dholi Block.

4: EXPERIMENTS FOR THE SECTIONAL OFFICERS OF THE INSTITUTE

Imperial Agricultural Chemist.—(a) Manurial experiment with organic and inorganic fertilizers on sugarcane, New Area, Dholi Block.

(b) Phosphate requirements of calcareous soil, Punjab field, Block A.

(c) Relative availability of different phosphates in calcareous soil, Punjab field, Block A.

(d) Experiments on the depressing effect of potash fertilisers and Gypsum in calcareous soil, Punjab field, Block A.

(e) Nitrogen requirements of calcareous soil, Punjab field, Block A.

(f) Green manuring experiment with sannhemp, sannhemp tops, *urid* (*Phaseolus Mungo* var. *Roxburghii*) and maize (control) on wheat, North Nepali field.

(g) Green manuring experiment with sannhemp, sannhemp tops, *urid* and soybean on wheat, Nepali field.

(h) Green manuring experiment with sannhemp and Mexican sunflower on wheat, Nepali field.

(i) Experiment on the yellowing of sugarcane leaves, New Area, Dholi Block.

(j) Experiment on manuring of potato, Punjab field, Block B.

(k) Manurial experiment with Kudada phosphate and its com-
posts on mustard, Punjab field, Block D.

Imperial Economic Botanist.—(l) Yield trial with arhar (*Cajanus indicus*), Chandman paddock.

Imperial Mycologist.—(m) Mosaic tonnage experiments with Co. 213 : mosaic *versus* mosaic-free cane, Silk-house Area.

VI. RESULTS OF FIELD EXPERIMENTS

1. MANURIAL EXPERIMENTS

(i) *Permanent manurial and rotation experiments in the Punjab field, Blocks C and D.*—In pursuance of the recommendations of the Board of Agriculture 1929, the altered scheme of these experiments was given effect to in 1930-31. The first cycle of the four-year eight-course rotation was completed in 1933-34, and during the year under report, the cropping scheme of the first year rotation was followed up. The yields in different plots are given below :

*Results of permanent manurial and rotation experiments for the year
1934-35*

Treatment	A SERIES			B SERIES		
	Kharif 1934	Rabi 1934-35		Kharif 1934	Rabi 1934-35	
	Maize grain per acre	Peas grain per acre	Barley grain per acre	Maize grain per acre	Barley grain per acre	Wheat grain per acre
GROUP I	lb.	lb.	lb.	lb.	lb.	lb.
1. No manure (Check plot No. 1).	816	426		966	318	
2. Farmyard manure @ 4,000 lb. per acre.	1,244	772		1,198	658	
3. Farmyard manure @ 8,000 lb. per acre.	1,457	1,073		2,041	934	
4. Farmyard manure @ 4,000 lb. per acre plus rape cake to supply 20 lb. nitrogen per acre at the time of last interculture.	1,749	1,020		2,149	1,058	
5. Rape cake @ 40 lb. nitrogen per acre, half to be applied just before <i>kharif</i> sowing and half to be applied at last interculture.	1,605	568		1,773	618	
GROUP II						
6. Sulphate of ammonia @ 40 lb. nitrogen per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> is sown it is to be applied in one dose in <i>kharif</i> .	1,026	310		906	424	
7. Sulphate of potash @ 50 lb. K_2O per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> crop is sown it is to be applied in one dose in <i>kharif</i> .	902	332		902	296	
8. Superphosphate @ 80 lb. P_2O_5 per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> is sown it is to be applied in one dose in <i>kharif</i> .	958	1,126		1,322	760	

Treatment	A SERIES			B SERIES		
	Kharif 1934	Rabi 1934-35		Kharif 1934	Rabi 1934-35	
	Maize grain per acre	Peas grain per acre	Bar'ey grain per acre	Maize grain per acre	Bar'ey grain per acre	Wheat grain per acre
	lb.	lb.	lb.	lb.	lb.	lb.
GROUP II— <i>contd.</i>						
9. Sulphate of potash @ 50 lb. K_2O per acre and superphosphate @ 80 lb. P_2O_5 per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> is sown they are to be applied in one dose in <i>kharif</i> .	878	1,324		1,090	772	
10. Sulphate of ammonia @ 40 lb. nitrogen, sulphate of potash @ 50 lb. K_2O and superphosphate @ 80 lb. P_2O_5 per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> is sown they are to be applied in one dose in <i>kharif</i> .	914	1,084		1,128	1,420	
11. Sulphate of ammonia @ 40 lb. nitrogen and superphosphate @ 80 lb. P_2O_5 per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> is sown they are to be applied in one dose in <i>kharif</i> .	818	1,276		791	1,100	
13. No manure (Check plot No. 2).	918	280		699	456	
14. Sulphate of ammonia @ 40 lb. nitrogen per acre, sulphate of potash @ 50 lb. K_2O per acre, half before <i>kharif</i> and half before <i>rabi</i> sowing, but in the year when <i>arhar</i> is sown they are to be applied in one dose in <i>kharif</i> .	898	211		864	564	
GROUP III.						
12. Green manure in conjunction with a purely cereal rotation.	Green manure	..	856	Green manure	..	508

Treatment	A SERIES			B SERIES		
	Kharif 1934	Rabi 1934-35		Kharif 1934	Rabi 1934-35	
	Maize grain per acre	Peas grain per acre	Barley grain per acre	Maize grain per acre	Barley grain per acre	Wheat grain per acre
GROUP III— <i>contd.</i>	lb.	lb.	lb.	lb.	lb.	lb.
15. Effect of green manure and leguminous crop in the rotation.	1,521	356	..	Green manure	1,224	.
16. As for plot No. 15 but with an additional application of superphosphate @ 80 lb. P_2O_5 per acre to be applied with green manure only.	1,909	922	..	Green manure	1,854	..
17. No leguminous crop and no green manure.	886	..	188	738	..	180
18. No manure (Check plot No. 3).	1,036	277	..	810	444	..

(ii) *The new manurial and rotation experiments in the Punjab field, Block A.*—This experiment completed its third year of rotation during the year under report. The following are the results of the experiments :

Treatment per acre	Mean yield per plot	
	Kharif Maize No. 2	Rabi Wheat P. 52
A. No manure	lb. 9·750	lb. 8·370
B. Farmyard manure * @ 8,000 lb.	15·157	15·976
C. Rape cake @ 40 lb. N.	22·395	12·406
D. Amm. Sulphate @ 40 lb. N.	15·375	9·734
E. Pot. Sulphate @ 50 lb. K_2O	11·170	9·058
F. Superphosphate @ 80 lb. P_2O_5	12·469	10·202
G. Pot. Sulphate @ 50 lb. K_2O and Superphosphate 80 lb. P_2O_5	9·763	8·006
H. Amm. Sulphate @ 40 lb. N, Superphosphate @ 80 lb. P_2O_5 and Pot. Sulphate @ 50 lb. K_2O	17·276	14·644
I. Amm. Sulphate @ 40 lb. N and Superphosphate @ 80 lb. P_2O_5	17·376	13·619
J. Amm. Sulphate @ 40 lb. N and Pot. Sulphate @ 50 lb. K_2O	14·788	10·651

Fisher's "Z" test was applied and the general effect of treatments was found to be significant at the one per cent. level.

*Composition of farmyard manure :—N—0·86% ; P_2O_5 —0·31% and K_2O —0·78%.

Fisher's 't' test was also applied and the differences between the treatments were significant.

Maize

Critical difference = 4.268 ($P = .01$).

Critical difference = 3.220 ($P = .05$).

Conclusions :— $C > I = H = D = B = J > F = E = G = A$.

Wheat

Critical difference = 3.187 ($P = .01$).

Critical difference = 2.404 ($P = .05$).

Conclusions :— $B = H = I > C = J = F > D = E = A = G$.

(iii) *Green manuring experiment in the Punjab field, Block B.*—The experiment was conducted on the lines given in the last year's report. The results are tabulated below :—

Treatment	Mean yield per plot of wheat grain P. 52 (Area of each plot = 0.03 acre)	"z" test	Critical difference
	lb.		
1—Sannhemp . . .	22.71	Not significant.	7.856 ($P = .05$)
T. 2—Cowpea . . .	21.52		
T. 3—Guar . . .	28.71		
T. 4—Meth . . .	20.54		
T. 5—Soybean . . .	15.38		
T. 6—Velvet bean . .	24.11		

Conclusions : T. 3 > T. 4 and T. 5 ; T. 6 > T. 5 ; T. 1 = T. 2 = T. 3 = T. 6.

(iv) *Manurial experiments with rape-cake and superphosphate on sugarcane Co. 213 in Gonthri field.*—These experiments were laid out in Randomised Blocks with six replications for each treatment. The manures were applied at the time of planting, and the amount of phosphoric acid in rape-cake was deducted from the main dressing of superphosphate.

The results are summarised below :—

Treatment per acre	Sucrose per cent. (Febv.)	Mean tonnage yield per plot (Area of each plot = 0.05 acre)	'z' test	Critical difference
		lb.		
T. 1—No manure	15.08	2816.67	Signifi- cant at 1 per cent level.	297.18 ($P=0.01$)
T. 2—40 lb. N + 50 lb. P_2O_5 .	14.37	3379.67		
T. 3—60 lb. N + 50 lb. P_2O_5 .	14.84	3349.67		
T. 4—80 lb. N + 50 lb. P_2O_5 .	13.80	3407.17		
T. 1—No manure	16.06	2472.17	Signifi- cant at 1 per cent level.	221.38 ($P=0.01$)
T. 2—50 lb. P_2O_5 + 40 lb. N .	14.58	3023.67		
T. 3—75 lb. P_2O_5 + 40 lb. N .	14.64	3059.67		
T. 4—100 lb. P_2O_5 + 40 lb. N .	14.81	2923.00		

Conclusions : T. 2=T. 3=T. 4 > T. 1.

The conclusions deduced from these manurial trials, carried out for the last three years show that the application of 40 lb. nitrogen in the form of rape cake and 50 lb. P_2O_5 as superphosphate is the most economical treatment in the Pusa soils. Its use along with the Pusa improved method of sugarcane cultivation is therefore recommended.

(v) *Green manuring experiment with berseem on sugarcane Co. 213 in the New Area, Dholi Block.*—The experiment was designed and laid out during the year under report in Randomised Blocks with six replications. The different treatments included in the experiment are given below—

Treatments per acre :—

T. 1—Berseem green manure.

T. 2—Standard manure :—40 lb. N as rape-cake and 50 lb. P_2O_5 as superphosphate.

T. 3—10 tons farmyard manure.

T. 4—20 tons farmyard manure.

T. 5—Complete minerals :—

40 lb. N as amm. sulphate,

50 lb. P_2O_5 as superphosphate and

40 lb. K_2O as pot. sulphate.

Results of the experiment :—

Treatments	Sucrose per cent (Feby.)	Mean tonnage yield per plot (Area of each plot = 0.05 acre)	'z' test	Critical difference
		lb.		
T. 1 . .	17.78	1240.67	Significant at the 1 per cent level.	353.42 (P = .01)
T. 2 . .	16.91	2489.50		259.14 (P = .05)
T. 3 . .	17.16	2452.83		
T. 4 . .	16.91	2809.00		
T. 5 . .	17.39	2088.33		

Conclusions :—T. 4 > T. 1, T. 2, T. 3 and T. 5 ; T. 2 > T. 1 and T. 5 ; T. 3 > T. 1 and T. 5 : T. 5 > T. 1.

The experiment is being continued and further observations will be taken of the ratoons next year.

(vi) *Effect of silt and farmyard manure on sugarcane yield, New Area, Dholi Block.*—The second year's experiment was carried out with Co. 213, and the results show that silt in bulk is of considerable advantage when ample farmyard manure cannot be obtained.

Treatments per acre	Average tonnage yield per acre	Percentage increase over F. Y. M.
	lb.	
Silt @ 68,556 lb.	61,115	4.4
Farmyard manure @ 32,920 lb.	58,433	..

2. VARIETAL YIELD TRIALS

(i) *Yield trials with maize for fodder and corn in the Punjab field, Blocks D and A.*—The three farm varieties of maize were tried against the local in double Latin Squares for fodder and

corn separately. The results of the experiments are tabulated below :

Variety	Mean yield per plot (Area of each plot= 0.016 acre)	' z ' test	Critical difference
<i>Fodder—</i>			
	lb.		
P. F. 1 . . .	317.56	Significant at the 5 per cent level.	53.19 (P=.01)
P. F. 2 . . .	322.56		38.46 (P=
P. F. 3 . . .	362.50		.05)
Local . . .	299.56		
<i>Corn—</i>			
P. F. 1 . . .	28.21	Significant at the 1 per cent level.	3.663 (P=
P. F. 2 . . .	32.34		.01)
P. F. 3 . . .	34.95		
Local . . .	29.90		

Conclusions :—Fodder—P. F. 3 > P. F. 2 = P. F. 1 = Local

Corn—P. F. 3 > P. F. 1 = Local;

P. F. 2 > P. F. 1.

(ii) *Yield trials with soybean for fodder and seed in the Punjab field, Blocks B and D.*—The results of the second year's trial confirm those given in the last year's report.

Variety	Mean yield per plot (Area of each plot = 0.019 acre)	' z ' test	Critical difference
Fodder—			
	lb.		
No. 1—Yellow . .	259.21	Significant at the 1 per cent level.	21.815 (P= .01)
No. 2—Chocolate .	292.00		
No. 3—Black . .	228.96		
Seed—			
	(Area of each plot=0.015 acre)		
No. 1—Yellow . .	18.11	Significant at the 1 per cent level.	1.926 (P= .01)
No. 2—Chocolate .	18.03		
No. 3—Black . .	15.62		

Conclusions :—Fodder—No. 2 > No. 1 > No. 3.

Seed—No. 1 = No. 2 No. 3.

(iii) *Yield trial with gram in the Punjab field, Block B.*—The results of the third year's trial with gram varieties are given below :—

Variety	Mean yield per plot (Area of each plot = 0.022 acre).	'z' test	Critical difference
	lb.		
T. 17	22.05	Significant at the 1 per cent level.	6.59 (P = .01)
T. 25	18.90		
T. 28	19.65	4.93 (P = .05)	
T. 58	24.17		
P. F. 3	23.80		
P. F. 6	14.17		
P. F. 11	27.59		
P. F. 17	20.39		

Conclusions :—P. F. 11 > T. 17, T. 25, T. 28, P. F. 6 and P. F. 17 ;
T. 58 > T. 25 and P. F. 6 ; P. F. 3 > T. 25 and P. F. 6 ; T. 17 > P. F. 6 ; P. F. 17 > P. F. 6 ; T. 28 > P. F. 6.

(iv) *Yield trial with field-pea (Pisum arvense) in the Punjab field, Block B.*—The experiment was conducted in a set of four Latin Squares with three varieties.

Variety	Mean yield per plot (Area of each plot = 0.019 acre)	'z' test	Critical difference
	lb.		
P. F. 6	15.33	Not significant.	2.585 (P = .05)
P. F. 7	14.40		
P. F. 8	17.54		

Conclusions :—P. F. 6 = P. F. 7 < P. F. 8.

(v) *Yield trial with pea (Pisum sativum) in the Punjab field, Block B.*—Four varieties of peas were tested in double Latin Squares. The following are the results of the experiment.

Variety	Mean yield per plot (Area of each plot = 0.022 acre)	'z' test	Critical difference
	lb.		
P. F. 1	17.20	Significant at the 1 per cent level.	4.09 (P = .05)
P. F. 2	21.97		5.65 (P = .01)
P. F. 3	23.21		
P. F. 4	15.81		

Conclusions :—P. F. 2 = P. F. 3 > P. F. 1 = P. F. 4.

(vi) *Tonnage yield trial with sugarcane varieties Co. 210, Co. 213, Co. 313 and Co. 331 in Gonhri field.*—The varieties were tried in Randomised Blocks with six replications for each. The crop was cut in the middle of the cane season.

Variety	Mean yield per plot (Area of each plot = 0.05 acre)	'z' test	Critical difference
	lb.		
Co. 210	3237.17	Significant at the 1 per cent level.	224.65 (P= .01)
Co. 213	3049.00		162.45 (P= .05)
Co. 313	3065.17		
Co. 331	3911.33		

Conclusions :—Co. 331 > Co. 210, Co. 213 and Co. 313
Co. 210 > Co. 213 and Co. 313.

(vii) *Tonnage yield trial with sugarcane varieties Co. 213 and Co. 331 in Gonhri field.*—The experiment was laid out according to Beaven's half-drill-strip arrangement with fourteen replications for each variety. The crop was allowed to stand over and harvested at the end.

Area of each plot = 1/20 acre.	lb.
Mean difference in favour of Co. 331	885.00
Standard error	49.38
Critical difference (P = .01)	148.73
Result—Co. 331 > Co. 213.	

(viii) *Tonnage yield trial with sugarcane varieties Co. 210 and Co. 213 in the New Area, Dholi Block.*—This experiment has now been carried out for five years, and it will be seen that during the year under report, Co. 210 has excelled Co. 213. The tonnage-yield of these varieties depends much upon the monsoon variation and local soil conditions. The experiment was conducted on same lines as before with twelve replications for each variety.

Area of each plot = 1/20 acre.	lb.
Mean difference in favour of Co. 210	463.33
Standard error	40.82
Critical difference (P = .01)	126.78

3. MISCELLANEOUS EXPERIMENTS

(i) *Effect of speed of tractor-drawn implements on soil tilth and crop yield.*—The third year's experiment was conducted in Brick-field No. 2 on the lines detailed in the two previous reports.

A—Ploughing and harrowing at 5 miles per hour.

B—Ploughing and harrowing at $2\frac{1}{2}$ miles per hour.

The 5-furrow plough working at $2\frac{1}{2}$ m.p.h. kept the furrows open and the furrow slice was not broken properly, while the 3 furrow plough working at 5 m.p.h. turned the furrows completely over, the furrow slice was pulverised thoroughly and the ploughed surface was smooth.

Oats B. S. I. was grown in *rabi* and the results given below show that the higher speed does not affect crop production.

Area of each plot = 0.095 acre.

Mean difference in favour of 5 miles speed = 0.306 lb.

Standard error = 1.856 lb.

Critical difference ($P = .05$) = 3.916 lb.

(ii) *Spacing experiments with maize P. F. 2 for fodder and corn in the Punjab field, Block D.*—The results of this year's experiments indicate clearly that the spacing of nine inches within rows gives a higher yield of fodder and corn than the other treatments. The trial was conducted in double Latin Squares as before.

Spacing	Mean yield per plot (Area of each plot = 0.016 acre)	'z' test	Critical difference
lb.			
<i>For fodder—</i>			
T. 1—9 inches . .	316.19	Significant at the 1 per cent level.	36.51 ($P = .01$)
T. 2—12 inches . .	277.75		
T. 3—15 inches . .	279.19		
T. 4—18 inches . .	257.06		
<i>For corn—</i>			
T. 1—9 inches . .	25.25	Significant at the 1 per cent level.	3.10 ($P = .01$)
T. 2—12 inches . .	22.49		2.24 ($P = .05$)
T. 3—15 inches . .	22.20		
T. 4—18 inches . .	20.74		

Conclusions :—T. 1 > T. 2 = T. 3 = T. 4.

(iii) *Experiments on the spacing of sugarcane and arrangement of sets at planting with Co. 210 in the New Area, Dhuli Block.*—This experiment was conducted for the second time during the period under report. The results show that the spacing of

2½ feet is not advantageous, as more setts are required. The arrangement of 'eye to eye' with ordinary seed is advisable, while 'end to end' with good seed is equally good.

Treatment	Average tonnage yield per acre	'z' test	't' test
	lb.		
3 feet spacing	53,887	} Not signi- ficant	} Not signi- ficant
2½ feet spacing. . . .	53,313		
End to end	53,962	} Do. .	} Do. .
Eye to eye	53,238		

4. SECTIONAL EXPERIMENTS

The results of the experiments conducted for the Sectional Officers of the Institute have been incorporated in their respective reports.

VII. SUGARCANE VARIETAL WORK

The importation of new varieties of sugarcane from Coimbatore and their testing and multiplication were continued. Three new varieties of cane Co. 432, Co. 433 and Co. 434 were received in March 1933.

The importance of this work can be indicated by stating that the three varieties of cane Co. 331, Co. 313 and Co. 299, the seed of which was distributed in large quantities last year after all sorts of trials, have proved extremely successful on the growers' estates, and there is a regular demand for the seed of these varieties. When fully spread, the grower will be benefitted by their heavy tonnage and the factory by running the mills for longer period, as Co. 299 and Co. 313 are early canes and Co. 331 a late one.

The following varieties of cane were grown on a field scale during 1934-35.

Co. 210, Co. 213, Co. 214, Co. 281, Co. 299, Co. 303, Co. 313, Co. 331, Co. 337, Co. 339, Co. 343, Co. 344, Co. 387, Co. 388, Co. 393, Co. 395, Co. 396 and Co. 397.

These have again been planted on a commercial basis. The average yield and analysis results for the year under report are given below :—

Results of chemical analysis and tonnage yields of sugarcane varieties during 1934-35

Sugarcane variety	Field	Sucrose per cent in juice				Area in acres	Average tonnage yield per acre in maunds*
		Novr. 1934	Decr. 1934	Jany. 1935	Feby. 1935		
Co. 210 . .	New Area . .	15.91	13.54	14.88	16.90	8.21	689.78
	Gonhri . .	...	...	...	...	5475	726.80
Co. 213 . .	New Area . .	...	16.44	16.82	17.96	8.59	531.80**
	Gonhri . .	...	...	...	...	62101	705.57
Co. 214 . .	New Area . .	14.98	17.04	17.57	17.41	2.45	466.39
	Gonhri . .	...	...	...	...	.37	330.00
Co. 281 . .	New Area . .	11.64	17.32	17.32	19.52	2.467	712.20
Co. 299 . .	New Area . .	13.24	16.37	17.43	16.63	4.82	509.65
	Gonhri . .	15.33	...	...	...	.37	506.30
Co. 303 . .	New Area . .	...	...	...	...	.68	495.39
Co. 313 . .	Gonhri . .	13.40	15.76	17.05	17.47	.9175	711.87
	New Area . .	...	...	...	...	1.12	656.89
Co. 331 . .	New Area . .	...	14.04	15.11	16.55	2.75	761.53
	Gonhri . .	...	...	...	...	2.1809	907.48
Co. 337 . .	Gonhri . .	16.61	16.87	17.85	16.93	.74	343.90
Co. 339 . .	Gonhri . .	15.36	16.35	16.44	15.40	.22	383.60
Co. 343 . .	New Area . .	...	14.35	16.79	16.92	.43	462.67
Co. 344 . .	Do. . .	16.22	16.70	16.18	15.48	.62	510.12
Co. 387 . .	Do. . .	14.75	15.99	17.24	17.31	.082	545.73
Co. 388 . .	Do. . .	14.43	15.71	16.70	18.57	.046	540.00
Co. 393 . .	Do. . .	15.93	17.04	17.05	18.41	.046	440.05
Co. 395 . .	Do. . .	14.59	16.67	16.72	17.70	.092	667.39
Co. 396 . .	Do. . .	17.72	17.07	17.36	17.91	.046	378.26
Co. 397 . .	Do. . .	15.19	16.04	17.26	16.84	.092	367.17

* 1 maund = 82.28 lb.

** Attacked by borers.

The following varieties were under multiplication in the nursery at New Area—

- (a) Varieties imported from Coimbatore in 1931—Co. 347 and Co. 348.
- (b) Varieties imported from Coimbatore in 1932—Co. 381, Co. 382, Co. 384 and Co. 386.
- (c) Varieties imported from Coimbatore in 1933—Co. 360, Co. 366, Co. 368, Co. 369, Co. 370, Co. 371, Co. 373, Co. 374, Co. 375, Co. 377, Co. 378, Co. 381*, Co. 382*, Co. 384*, Co. 386*, Co. 391, Co. 394, Co. 408, Co. 412, Co. 413, Co. 417, and Co. 419.
- (d) Varieties imported from Coimbatore in 1934—Co. 420, Co. 421, Co. 422, Co. 423, Co. 424, Co. 425, Co. 426, Co. 427, Co. 428, Co. 429, Co. 430, Co. 431, Co. 500, Co. 501, Co. 502, Co. 503, Co. 504, Co. 505, Co. 506, Co. 507, Co. 508, Co. 509, Co. 510, Co. 511, Co. 512, Co. 513, Co. 514, Co. 515, and Co. 516.

Out of the above varieties Co. 360, Co. 373, Co. 408 failed to germinate as they were all eaten up by white ants.

* Repeats.

Out of 50 varieties that survived, 45 were analysed chemically. The results were not conclusive, as the material subjected to analysis was very little—one cane only in many varieties. Co. 377, Co. 378, Co. 421, Co. 422 and Co. 423 look promising from the habit of growth and will be carefully watched next year.

VIII.—MISCELLANEOUS CROPS GROWN FOR THE SECTIONAL OFFICERS OF THE INSTITUTE

(1) Crops were grown for the Imperial Economic Botanist in the Agricultural Section for seed multiplication as well as for varietal yield trial. The average yield per acre of each variety is given below :

Crop	Field	Area in acres	Outturn of grain in lb.	
			Actual	Per acre
<i>Arhar</i> T.15	Chandman paddo-dock.	0.109	201.71	1850.55
T.16	Do.	0.109	151.11	1386.33
T.24	Do.	0.109	229.01	2101.00
T.41	Do.	0.109	174.82	1603.85
T.51	Do.	0.109	148.92	1366.24
T.64	Do.	0.109	234.89	2154.03
T.69	Do.	0.109	180.58	1748.44
T.80	Do.	0.109	175.27	1607.98
T.50	Do.	0.109	166.83	1530.55
T.82	Do.	0.109	190.46	1747.34
Local	Do.	0.109	195.84	1796.69
T. 5	Bhograsan .	5.00	6128.20	1025.60
T.24	Do.	9.00	11139.50	1237.70
T.51	Do.	9.10	7792.50	855.10
T.80	Do.	4.40	3404.60	773.70
<i>Safflower</i> T.1	Punjab field Block D.	0.0625	70.40	1126.40
T.2	Do.	0.0625	45.80	732.80
T.3	Do.	0.0625	40.10	641.60
T.4	Do.	0.0625	61.20	979.20
<i>Barley</i> T.21	Do.	2.00	2037.60	1018.80
T.21	N. Pangarbi	5.75	12054.80	2096.49
<i>Hibiscus</i> T.3	Nepali .	0.50	52.40	..
T.6	Do.	0.50	83.30	..
<i>New Hibiscus</i> (seed).	Do.	0.10	29.80	..
<i>New Hibiscus</i> (fibre).	Do.	0.50	59.70	..
<i>Oats</i> B. S. II	Brickfield No. 2 .	2.00	1992.80	996.40
<i>Oats</i> H. J. .	Do.	6.00	5428.80	904.80
<i>Oats</i> H. C. .	Do.	3.00	1890.50	630.17

Crop harvested and utilised by the I. E. B.

(2) The following crops were grown in small plots for the Imperial Entomologist during the year under report :

Kharif

Maize, *juar* (*Andropogon Sorghum*), *bajra* (*Pennisetum typhoides*), *mung* (*Phaseolus radiatus*), *urid* (*Phaseolus Mungo* var. *Roxburghii*), cowpeas, soybean, *meth* (*Phaseolus aconitifolius*), *guar* (*Cyamopsis psoralioides*), sannhemp, Roselle, *til* (*Sesamum indicum*), sweet potato, turmeric, ginger, castor, sunflower and sugar-cane—Co. 210, Co. 213, Co. 214 and Co. 331 (February, 1934) ; Co. 210, Co. 213, Co. 299 and Co. 331 (February, 1935).

Rabi

Wheat, oats, barley, gram, peas, Java indigo, lentil, chillies, potato, tobacco, linseed, mustard, and safflower.

IX.—MACHINERY

1. STEAM TACKLE

The steam ploughing tackle consisting of two ploughing engines, one gang-plough, one disc-harrow, one roller and one spring tine-cultivator was transferred to Delhi, at the end of May, 1935 for levelling agricultural lands at the new site of the Imperial Institute of Agricultural Research.

2. TRACTORS

Trials with tractors (crude-oil and kerosene oil), the details of which have been given in the last year's report were continued. The new model 18/30 H. P. Marshall crude-oil tractor which was received in exchange of the old 15/30 H. P. model worked satisfactorily. The total number of working hours with four tractors was 931·84 as compared with 957·93 in the last year with three tractors. The working cost and fuel consumption were considerably reduced during the year under report. This is due to the fact that the Marshall tractor was of a new design and the Lanz Bulldog and McCormick Deering were thoroughly overhauled and had new cylinders and pistons put on last year. The comparative figures of their working expenses are as follows :

Name of tractor	1933-34		1934-35	
	Fuel per hour	Total expenses per hour	Fuel per hour	Total expenses per hour
Lanz Bulldog (crude oil).	Galls. 1·50	Rs. a. p. 3 14 6	Galls. 1·24	Rs. a. p. 1 6 3
Marshall (crude-oil)	..	..	1·20	1 7 3
McCormick Deering (kerosene oil).	2·69	6 0 9	2·56	4 5 10

The 9/18 H. P. "Farmall" row crop tractor, purchased last year, was used with cultivating attachment in the sugarcane crop and proved very satisfactory. The working details for this tractor are being collected.

The results of the year's working with four tractors are given in the following statements :

Statements showing the output, consumption and cost of cultivation by tractor for the year 1934-35

1. SUMMARY OF THE WORK DONE

Name of Tractor	Ploughing		Harrow ploughing		Disc Harrowing		Grubbing		Reaping		Rolling		Drilling	
	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres
Leas Building semi-Diesel 15/30 H. P.	204.91	15.00	...	...	12.50	21.50	124.41	232.00	22.00	68.00	31.00	98.00	...	...
Marshall Fuel Diesel 18/30 H. P.	498.12	71.66	98.55	181.00	26.66	40.20	267.25	480.00	...	...	24.50	76.00	9.50	20.00
McCormick Deering 15/30 H. P. (K. oil).	170.66	...	28.00	50.00	52.25	119.00	77.91	174.00	...	...	5.0	16.00	7.50	27.00
Vickers 23/40 H. P. (K. oil).	58.15	5.50	...	...	47.50	102.00	5.15	12.50	...	...	...	...	...	...

2. ACREAGE PER HOUR

Name of Tractor	Working Hours		Ploughing		Harrow ploughing		Disc Harrowing		Grubbing		Reaping		Rolling		Drilling	
	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres
Leas Building semi-Diesel 15/30 H. P.	204.91	15.00	0.66	...	...	1.72	1.86	3.00	1.86	3.00	3.00	3.00	3.00	3.00	...	...
Marshall Fuel Diesel 18/30 H. P.	498.12	71.66	1.12	1.83	1.83	1.86	1.70	...	1.70	...	...	...	3.16	3.16	2.10	2.10
McCormick Deering 15/30 H. P. (K. oil)	170.66	...	...	1.78	1.78	2.27	2.23	...	2.23	...	...	...	3.20	3.20	3.60	3.60
Vickers 23/40 H. P. (K. oil)	58.15	5.50	0.90	...	...	2.14	2.88	...	2.88	...	...	...	...	...	...	...

3. FUEL CONSUMPTION

Name of tractor	Working hours	K. oil		Crude oil		Petrol		Engine and gear oil		Grease		Waste	
		Total	Per hour	Total	Per hour	Total	Per hour	Total	Per hour	Total	Per hour	Total	Per hour
Ians Bulldog Semi-Diesel 15/80 H. P.	204.91	galls. 10.56	0.05	galls. 255.53	1.24	galls. ...	...	galls. 33.90	0.16	lb. 32.00	0.15	lb. 9.50	0.04
Marshall Fuel Diesel 18/80 H. P.	498.12	5.11	0.01	601.30	1.20	...	...	100.47	0.20	32.50	0.16	29.25	0.05
McCormick Deering 15/80 H. P. (K. oil).	170.66	496.75	2.56	...	...	14.00	0.08	33.78	0.19	33.00	0.19	9.00	0.05
Vickers 23/40 H. P. (K. oil)	58.15	218.84	3.27	...	...	2.50	0.03	15.75	0.23	9.00	0.13	1.80	0.02

4. ANALYSIS OF TOTAL COST

Name of tractor	Kerosene oil	Crude oil	Petrol	Lubricants and waste	Wages of mistsries and water carriers	Wages of repairing staff	Spare parts	Total	Expenses per hour
Ians Bulldog Semi-Diesel 15/80 H. P.	Rs. s. p. 7 13 1	Rs. s. p. 111 12 7	Rs. s. p. ...	Rs. s. p. 56 15 0	Rs. s. p. 38 7 6	Rs. s. p. 50 0 0	Rs. s. p. 20 6 6	Rs. s. p. 235 6 8	Rs. s. p. 1 6 3
Marshall Fuel Diesel 18/80 H. P.	4 10 2	263 0 10	...	263 13 7	71 15 6	78 11 0	42 10 0	724 13 1	1 7 3
McCormick Deering 15/80 H. P. (K. oil)	320 12 0	...	22 12 0	88 4 0	30 8 2	104 7 0	178 11 6	745 6 8	4 5 10
Vickers 23/40 H. P. (K. oil)	142 14 6	...	3 4 0	41 13 11	16 10 10	22 6 0	138 15 0	366 0 3	6 4 8

5. COST PER ACRE

Name of tractor	Ploughing	Harrow-ploughing	Disc-harrowing	Grubbing	Reaping	Rolling	Drilling
	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
Lans Bulldog Semi-Diesel 15/30 H. P.	2 1 4	...	0 12 11	0 11 11	0 7 2	0 7 5	...
Marshall Fuel Diesel 18/30 H. P.	1 4 9	0 12 8	0 12 7	0 11 3	...	0 7 6	0 11 0
McCormick Deering 15/30 H. P. (K. oil)	...	2 6 9	1 14 3	1 15 3	...	1 5 10	1 3 5
Vickers 23/40 H. P. (K. oil)	6 14 9	...	2 14 10	2 10 3	...	...	...

Statement showing the cost of belt pulley work by tractors for the year 1934-35

Name of tractor	Working hours	Fuel and lubricants, etc.	Wages of mistsries and water carriers	Wages of repairing staff	Total	Expenses per hour
		Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
McCormick Deering 15/30 H. P. (K. oil)	108.00	230 0 6	23 4 2	8 6 8	261 11 4	2 6 9
Vickers 23/40 H. P. (K. oil)	8.50	25 12 4	2 14 8	...	28 11 0	3 5 11

3. DUNLOP PNEUMATIC EQUIPMENT FOR BULLOCK CARTS

After the preliminary tests, the results of which have been published in the September issue of the *Agriculture and Livestock in India*, 1934, the four trial carts fitted with Dunlop pneumatic equipment were constantly used throughout the year for ordinary carting work on the Farm for testing the life of the tyres and tubes. There was no sugarcane carting for the mill, as all the cane grown during the year was utilised in planting. Out of the eight tyres and eight tubes originally put on these carts, two tyres and three tubes were damaged and subsequently replaced with new ones. No sign of wear and tear is yet visible on the axles and hubs.

Twelve standard wooden cart bodies were made in the Farm workshop, fitted with Dunlop pneumatic equipment and sent to Delhi for use at the New Site of the Imperial Institute of Agricultural Research.

Three standard wooden cart bodies fitted with Dunlop equipment were made for the Raja Sugar Factory and the Manager, Gauri Bazaar Factory, at standard rates for use as demonstration carts in those districts.

X. CATTLE BREEDING

The strength of the Pusa Pedigree Sahiwal herd at the beginning of the year under report was 217 head. The cows in the milch herd numbered 54, and the total milk produced during the year was 2,52,732 lb. as against 3,00,690 lb. during the last year. The percentage of cows in milk was sixty as compared with sixty-six in the previous year.

While the herd was settling down to their normal condition after last year's earthquake disaster, they were, unfortunately, visited by a severe form of Foot and Mouth disease in January 1935, and this not only disturbed their metabolic and productive equilibrium, but it has left its marks on their constitution up to the time of writing this report. It may be noted that the herd was free from any attack of Foot and Mouth disease during the last eight years. The economic importance of Foot and Mouth disease is keenly realised in the severe losses from the long period of inactivity of the affected animals, from the loss in body weights, from diminished milk production, and through the loss of young calves below three months' age.

The following experiments that were in progress and mentioned in the previous report, are being continued, but there was a definite set-back during the period of the outbreak of the disease in all animals under various experiments. They are gradually coming back to their normal.

1. Special calf rearing experiments in relation to early maturity.



Champion No. 653—Fairy mixture—sold to S. Howard, Sept. 1, 1903. Milk yield—6,846 lb. in 261 days. She is expected to give over 7,500 lb. in her first lactation.



Jaswant No 636—Early maturity type of Sahiwal bull. He started to calve at the age of one year and ten months

2. Four time milking of cows.
3. Pre-milking and handling of heifers and cows.
4. Determination of the herd butter fat.
5. The early maturity experiments.

Milk Yield.—In spite of the severe attack of the Foot and Mouth disease, the average herd yield per cow per day was 19.1 lb. against 18.7 lb. in last year.

TABLE III in Appendix shows the best cows and heifers which have completed their lactation during the year. There were eight 8,000 lb. milkers and one 6,045 lb. heifer and five heifers over 5,000 lb.

TABLE IV in Appendix shows the number of cattle sold during the year and the prices obtained. This year better prices were realised than last year, and the demand for the pedigree stock continues.

Calf Rearing.—The year showed a higher percentage of mortality among the pail-fed calves—from 13.7 to 24.2 which was due to the unfortunate incident of Foot and Mouth disease among the young calves. Eleven calves died from this disease.

To find out the normal growth standard of the Sahiwal breed, data are being collected of weight and body measurements of every animal of this herd and young stock from birth. These data will be of great value to show how the stock could be grown most economically with reasonable rapidity, so that inherited growth potentialities may be realised to the fullest extent while they are young.

In collaboration with the Imperial Agricultural Chemist, Pusa, a series of feeding experiments, to find out a suitable balanced ration for the dairy cattle under Indian conditions, were conducted and the results will be published in due course.

XI. PUBLICATIONS

1. Sayer, Wynne . . . Feeding and handling experiments on the Pusa pedigree Sahiwal herd (Second report, 1933-34), *Agri. & Livestock in India*, 4, 1934, 481—494.
2. ————— . . . Tests on Dunlop pneumatic equipment for farm carts, Season 1933-34, *Agri. & Livestock in India*, 4, 1934, 524—533.
3. ————— . . . Tables of pail-fed calf weights during ordinary and special feeding, *Agri. & Livestock in India*, 4, 1934, 633—644.

XII. PROGRAMME OF WORK FOR 1935-36

1. Cultivation of sugarcane on an area of 322 acres on a commercial basis.
2. Continuation of the permanent manurial and rotation experiments in the Punjab field.

3. Continuation of the new manurial and other experiments which are at their stage of completion.
 4. Isolation of pure types of cowpeas.
 5. Study of new sugarcane varieties which have been received from Coimbatore.
 6. Experiments with various types of motor tractors and general tractor implements for collection of data and determination of most suitable types of tractors and implements for Indian conditions.
 7. Line breeding investigations with a pedigree herd of Sahiwal cattle with special reference to the transmission of milch characters.
 8. Special feeding of young calves with a view to early maturity to lengthen the profit period of the average Sahiwal cows and bulls.
 9. Cultivation of 300 acres of land at the Agricultural Sub-station, Karnal.
 10. Training of Post-graduate students.
 11. Touring and advisory.
 12. Gradual shifting of the Section to Delhi and Karnal.
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(2) AGRICULTURAL SUB-STATION, KARNAL

The Imperial Agricultural Sub-station, Karnal, was opened in October, 1935, and Mr. Kashi Ram, Superintendent, Botanical Sub-station, Karnal, remained in charge. He was assisted by Mr. Lachman Das, Graduate Fieldman, Agricultural Section, from the 12th December, 1934. On transfer of these officers to Delhi in May 1935, Mr. Hukam Singh, B.Sc. (Agri.), Offg. Superintendent, Botanical Sub-station, Karnal took over charge and Mr. J. N. Bhowmick relieved Mr. Lachman Das.

Under orders from the Director of the Imperial Institute of Agricultural Research, the Superintendent, Imperial Cattle Breeding Farm, handed over to the Superintendent, Botanical Sub-station, Karnal, an area of 119·17 acres of land (from Plot No. 5, I. C. B. Farm, Karnal). It was taken over on the 28th September 1934, on behalf of the Imperial Agriculturist, Pusa, for growing fodder for cattle engaged at the new site of the Imperial Institute of Agricultural Research, Delhi. Another 198 acres of land from Block Nos. 4 and 5 were handed over to the Superintendent, Botanical Sub-station, Karnal, on the 16th June 1935.

In Block No. 5, an area of 53·5 acres was put under gram T. 17 and 63·25 acres under oats hybrid J. 1,323 maunds of oats and 968·03 maunds of gram were obtained from the fields as a result of harvest. The average yield per acre for oats hybrid J. was 20·32 maunds and that for gram T. 17 was 18·1 maunds. Condition of crops was satisfactory except that the frost and hailstorm did some damage to gram, and showers in April caused the oats to lodge to some extent.

Forty pairs of Malvi bullocks were purchased from Central India in March–April and were sent to Karnal. Twenty-five pairs out of these were shifted to Delhi in May for the layout and levelling work at the New Imperial Institute of Agricultural Research and fifteen pairs were retained at Karnal for the cultivation work at the Agricultural Sub-station.

502 maunds of *bhusa* and 142·55 maunds of concentrates (oats and gram in 1 : 1 ratio) were sent to Delhi for the feed of cattle engaged in laying out lands for the Imperial Institute of Agricultural Research. 120 maunds of oats was also supplied to the Superintendent, Imperial Cattle Breeding Farm, Karnal, in exchange of 120 maunds of gram.

3. STATISTICAL BRANCH

(P. V. KRISHNA IYER, M.A., STATISTICIAN)

STATISTICAL WORK

Mr. P. V. Krishna Iyer, M.A., held the post of Statistician during the year under review.

In addition to advice and assistance given to workers of the different Sections at the Institute and to outsiders the following statistical studies were carried out.

The records of the Pusa herd were examined carefully in order to estimate the capacity of the various bulls, past and present, in improving their stock. The bulls were judged by their capacity to improve the milk yield of the progeny over the dam.

The possibility of applying in plant breeding work "The New Method of Goodness of Fit" put forth by Karl Pearson was discussed with the Assistant Economic Botanist and a note illustrating the method was sent for his use and guidance. The method is more reliable on account of the fact that the assumptions involved in it are fewer than " χ^2 " test. But unfortunately it is of more practical value in anthropometry than plant breeding.

RESEARCH WORK

Are assumptions in regard to fertility gradient curves in experimental plots valid? A short study of the behaviour of land in different years with same and different crops, viz., paddy, sorghum and cotton was made with some figures supplied by the Imperial Agricultural Chemist. In the case of paddy there was close correlation between the yields in different years from the same field. But in the case of other crops the correlation was very small showing thereby, that the method of adjustment of yield using previous crop records is not applicable for crops like sorghum and cotton.

Statistical study of milk yields—Sahiwal herd.—The records of the dairy were carefully gone through and data collected as to supply information on the following points connected with the Sahiwal herd :—(1) Mean and standard deviation of milk yield, service period, dry period, calving interval and age at first calving, (2) Relations between total milk yield, age, season of calving, service period and dry period, (3) Average gestation period for bull calves and cow calves, (4) Lactation curves for cows calving at different ages in different seasons.

The results of the analysis so far completed are given below :

The age at first calving was available for 411 cows and it was found that the Sahiwal herd in general could be expected to calve at the age of three years and 4.78 months. The distribution was not normal. The mode was at three years and 6.93 months.

In order to find out whether there was any improvement in the stock with the lapse of time, an attempt to divide the data into the following groups was made :—

Group I Cows calved during 1904—1913.

Group II „ „ „ 1914—1923.

Group III „ „ „ 1924—1934.

The results of the analysis are shown below :

Mean	(Distance between mean and mode in months)	Standard deviation (months)
Group I.—3 Yrs. 3·58 Mths. \pm ·5083	·8984 \pm ·7806	3·77 \pm ·3595
Group II.—3 Yrs. 9·36 Mths. \pm ·4222	·6150 \pm ·7514	5·39 \pm ·2985
Group III.—3 Yrs. 1·24 Mths. \pm ·3700	2·5931 \pm 1·0764	5·14 \pm ·2616
All together 3 Yrs. 4·78 Mths. \pm ·3117	2·1507 \pm ·5739	6·32 \pm ·2204

The foregoing analysis shows that the age at first calving of Group III cows was less than that of Group I and Group II. This may perhaps be due to the improvement of the herd stock during the last ten years.

The average service period of the Pusa Sahiwal herd for the years 1904—1934 was found to be approximately 197 days. There was practically no significance between the service period at different ages, showing that there is no correlation between service period and age. On the whole the data showed that the service period was very high which might be due to sterility and holding off in the herd.

In addition to the general average service period, the mean service period for the years 1904—1913, 1914—1923 and 1924—1934 was calculated separately for different ages and are shown in the table below.

Lactation	Mean (days)	Standard Deviation
(1904—1934) Service period Groups I, II & III together		
1st	215·2972 \pm 8·9515	121·7539 \pm 6·3297
2nd	204·7368 \pm 8·8813	116·1379 \pm 6·2900
3rd	192·1476 \pm 9·3866	114·5775 \pm 6·6373
4th	183·0081 \pm 10·5152	116·6190 \pm 7·4354
5th	201·3953 \pm 13·7283	127·3108 \pm 9·7073
6th	182·7536 \pm 13·6673	113·0310 \pm 9·6219
7th	165·8140 \pm 16·7803	110·0364 \pm 11·8656
8th	200·0000 \pm 28·4030	133·2216 \pm 20·0840
9th	180·0000 \pm 28·1425	105·2996 \pm 19·8997
10th	210·0000 \pm 64·1249	143·3876 \pm 45·3431
Whole	197·2430 \pm 4·0207	118·3214 \pm 2·8431

Lactation	Mean (days)	Standard Deviation
(1904—1913) Group I (Service Period)		
1st	182.4320 ± 14.7630	89.7998 ± 10.4390
2nd	227.4468 ± 17.8680	122.4822 ± 12.6331
3rd	169.0000 ± 17.0557	107.8700 ± 12.0602
4th	179.6552 ± 23.3090	125.5229 ± 16.4819
5th	195.8333 ± 31.2650	153.1666 ± 22.1076
6th	164.1666 ± 23.6960	116.0862 ± 16.7555
7th	102.3077 ± 20.6286	74.3774 ± 14.5866
8th	203.3334 ± 45.2941	135.8823 ± 32.0277
9th	187.5000 ± 39.4478	111.5755 ± 27.8939
10th	210 —	—
Whole	185.1724 ± 7.8014	118.8276 ± 5.5164

(1914—1923) Group II (Service period)

1st	236.8650 ± 13.5108	132.3782 ± 9.5536
2nd	203.3334 ± 13.0256	110.3817 ± 9.2105
3rd	209.7402 ± 13.9926	122.7844 ± 0.8942
4th	205.0000 ± 14.6990	121.2106 ± 10.3937
5th	226.6854 ± 19.8310	126.9803 ± 14.0227
6th	199.2306 ± 21.9685	112.0179 ± 15.5341
7th	207.5000 ± 27.3358	109.3435 ± 19.3293
8th	198.5714 ± 48.7090	128.8720 ± 34.4425
9th	203.3334 ± 78.4108	135.8116 ± 55.4448
10th	310.0000 ± 139.9878	197.8181 ± 98.9090
Whole	215.0476 ± 6.0261	123.4990 ± 4.2611

(1924—1934) Group III (Service period)

1st	198.8461 ± 15.9308	114.0435 ± 11.2711
2nd	180.0000 ± 14.7173	93.0806 ± 10.4067
3rd	178.7500 ± 17.2010	97.3036 ± 12.1630
4th	114.6154 ± 8.8222	44.9844 ± 6.2382
5th	158.5714 ± 17.4901	80.1499 ± 12.3674
6th	183.6842 ± 25.9230	112.9956 ± 18.3332
7th	177.1428 ± 32.7508	118.0847 ± 23.1583
8th	196.6667 ± 64.6374	158.3287 ± 45.7055
9th	136.6667 ± 46.6908	80.8708 ± 33.0153
10th	110.0000 ± 40.0000	56.5685 ± 28.2438
Whole	175.4884 ± 7.0206	102.9422 ± 4.9643

The above table leads us to the fact that sterility and holding off were more during the years 1914—1923 and that it was decreasing during the last decade.

Best size and shape of plots for experiments on canes.—The yields of Co. 210 from 968 plots of 1/242 acre each 60 ft. × 3 ft. were analysed with a view to determine the following :

(i) the best size and shape of plots for experiments on canes and (ii) the number of replications necessary in order to get satisfactory results.

The analysis showed that, as would be expected, the error of field experiments is partly governed by size and shape of plots. The percentage variation can be diminished by increasing the plot size up to 1/27th acre. The error is not diminished when we further increase the area. But for the sake of convenience it is desirable to have any area between 1/27 and 1/16th acre. As regards the shape of plots the investigation indicated that the error can be diminished to a slight extent by increasing the ratio of length to breadth upto a limit of thirty. But in practice it is better to adjust the size of plots in such a way as to have the length, five to 10 times the breadth.

The number of replications required depends on the percentage variation; the smaller the variation the fewer the number of replications required and *vice versa*. For land of average variability it is necessary to have 6 to 9 replications.

In the course of the above investigation there was occasion to verify the following remarks of Mr. T. Eden and Dr. R. A. Fisher, *Jour. Agri. Sci.*, Vol. XXIX, pp. 210-231: "The question as to how much soil heterogeneity variance makes its appearance in the one or the other sections into which the analysis of variance is divided depends entirely upon the inter-relation of plot size with block size and the type of soil heterogeneity encountered".

In the case of randomised layouts it was found that efficient and satisfactory results could be obtained by arranging the plots in each block in as compact way as possible. The elimination of error for differences in the fertility of blocks decrease as the number of plots in each block increases. In any layout it seems that it is not advisable to have more than seven or eight treatments at a time. The truth of the above findings is being further investigated with more data.

The distribution of the ratio of the estimated co-efficient of variation in two samples.—The distribution of the ratio of the co-efficient of variation of two samples drawn from the same normal population was investigated and found that if $100v_1$ and $100v_2$ are the estimated percentage variations of two samples, the theoretical value of $\log_e v_1/v_2$ that can arise due to random sampling

$$\text{alone} = z + \frac{1}{2} \log_e \frac{1 + \left(1 - \frac{1}{n_1}\right) v_1^2}{1 + \left(1 - \frac{1}{n_2}\right) v_2^2} \text{ where } n_1 \text{ and } n_2 \text{ are the}$$

sizes of the samples and 'z' is Fisher's 'z' distribution given in Table VI of "Statistical Methods for Research Workers". If the

$$\text{observed value of } \log_e v_1/v_2 \text{ is } > z + \frac{1}{2} \log \frac{1 + \left(1 - \frac{1}{n_1}\right) v_1^2}{1 + \left(1 - \frac{1}{n_2}\right) v_2^2}$$

the two samples belong to entirely different populations. The above results are valid only if v_1 and v_2 are $< \frac{1}{2}$.

PUBLICATIONS

1. A statistical study of the Body Weight Figures of Special and Ordinary Fed Calves at Pusa, by P. V. Krishna Iyer, *Ind. Jour. of Vet. Sci. & Animal. Hus.*, 5, 1935, 251—265.

2. On some Factors that influence the Error in Field Experiments with special reference to Sugarcane, by Wynne Sayer and P. V. Krishna Iyer (*In the press*).

APPENDIX

TABLE I

Annual statement of Livestock as it stood on the 30th June 1935

Description of cattle	Number of animals from last year	Increase			Decrease					Total
		By birth	By transfer	From Farm	By death	By transfer	By sale	Sent back to Farm	Sent to Pinjra-pole	
Bulls for breeding	9	..	8	..	1	..	2	..	..	14
Bulls at New Area	1	..	..	..	..	..	..	..	..	1
Cows—milk herd	51	..	29	..	1	..	2	..	1	55
Cows for breeding	3	..	..	..	..	..	..	..	..	3
Cows for sale	4	..	14	..	1	..	9	..	..	1
Cows—old	2	..	..	..	1	..	..	..	..	1
Cow under observation	1	..	..	..	..	..	1	..	..	..
Cows at New Area	..	..	14	..	5	..	8	..	..	1
Young male stock in dairy	53	27	..	..	5	..	40	..	..	27
Young female stock in dairy	84	34	..	..	10	34	..	..	..	74
Young female stock at New Area	..	1	7	..	..	1	7	..	..	..
Bullocks	9	..	..	4	1	..	..	10	..	2
Total	217	62	72	4	25	72	68	10	1	179
Sheep—male stock	27	5	..	..	6	..	26	..	..	..
Sheep—female stock	50	4	..	..	4	..	50	..	..	..
Total	77	9	..	..	10	..	76	..	..	..

TABLE II
Statement of milk yield for the year 1934-35

Month	Total yield	Average yield per day	Average yield per cow per day	Number of cows			
				Total	In milk	Dry	Per- centage in milk
1934							
July . . .	23,004	742	20.1	54	37	17	68.5
August . . .	23,747	766	20.2	54	38	16	70.4
September . . .	20,160	672	17.7	55	38	17	69.1
October . . .	18,526	598	17.1	57	35	22	61.4
November . . .	15,977	533	17.8	55	30	25	54.4
December . . .	16,913	546	18.8	59	29	30	49.2
1935							
January . . .	19,806	639	20.0	50	32	18	64.0
February . . .	18,188	650	20.3	52	32	20	61.5
March . . .	19,600	632	21.1	51	30	21	58.8
April . . .	16,437	548	18.9	51	29	22	56.9
May . . .	15,892	513	18.3	54	28	26	51.8
June . . .	17,569	586	18.9	55	31	24	56.3
Average . . .	18,818	619	19.1	54	32	22	60.0
Average for 1933-34.	23,396	769	18.7	63	41	22	66.2

TABLE III
Lactations of some of the best cows and heifers during 1934-35

Name and No. of cow	Date of birth	No. of calving (in which she gave milk)	Quantity of milk	
			Lb.	Days
<i>Cows</i>				
Laruli 604	20-10-29	2	8,823	304
Chandrika 482	18-12-23	5	8,549	304
Amba 495	28-2-24	7	8,486	304
Makhi 557	14-10-26	5	8,049	306
Chengi 534	11-11-25	4	8,035	306
Muraoe 547	25-5-26	5	8,032	304
Brisoorti 609	28-2-30	2	8,009	306
Chakai 563	11-1-27	4	8,001	304
<i>Heifers</i>				
Laohesari 636	23-4-31	1	6,045	306
Biradki 635	16-4-31	1	5,533	303
Dulgi 630	11-1-31	1	5,416	304
Lajmari 638	25-5-31	1	5,312	309
Laohmati 632	28-2-31	1	5,250	306
Laohmohni 644	10-9-31	1	5,191	306

TABLE IV

Statement of cattle disposed off during the year 1934-35

Particulars	No. of cattle	Total price			Average			Average for 1933-34		
		Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.
Sahiwal cows	11	1,715	0	0	159	9	0	131	5	0
„ heifers	4	300	0	0	75	0	0	88	12	0
„ bulls	2	280	0	0	140	0	0	..		
„ young bulls	17	755	0	0	44	5	0	55	0	0
„ steerlings	22	700	0	0	31	13	0	..		
Total	56									

	Number of cattle
Sahiwal cows sold at nominal prices	8
„ heifer sold at nominal prices	1
„ cow-calves sold at nominal prices	2
Cross-bred bull calf transferred to Farm	1
Sahiwal cow sent to Pinjrapole	1
	13

TABLE V

Percentage of mortality amongst the pail-fed calves during 1933-34 and 1934-35

Year	Birth	Death	Percentage of mortality
1933-34	68	9	13.2
1934-35	62	15*	24.2

* Including eleven calves died of foot and mouth disease.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST

(F. J. F. SHAW, D. Sc., A. R. C. S., F. L. S., I. A. S.)

(1) BOTANICAL SECTION, PUSA

I. ADMINISTRATION

Dr. F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., held charge of the Section throughout the year ending June 30, 1935, but his headquarters were transferred to Delhi from 5th November 1934. Dr. B. P. Pal, M.Sc., Ph.D., F.L.S., held the post of Second Economic Botanist.

From the 1st July 1934, to 31st May 1935, Mr. R. D. Bose, Special Research Assistant, officiated as Assistant Economic Botanist. During this period Mr. R. B. Deshpande officiated as Special Research Assistant. With effect from May 24, 1935, Mr. Hukam Singh, Assistant, was transferred to the Botanical Substation, Karnal, *vice* Mr. Kashi Ram, transferred to Delhi to supervise the levelling and lay-out of the new site. Mr. Mohammad Umar and Dr. Swarn Singh were appointed as Assistants on the 1st November 1934 and 18th June 1935 respectively.

Two schemes, one for breeding potatoes for Northern India and another for breeding rust-resistant wheats with the collaboration of Prof. K. C. Mehta of Agra College, both financed by the Imperial Council of Agricultural Research, came into operation in April 1935. Short notes on these schemes which are under the supervision of Dr. Pal, the Second Economic Botanist, are provided separately.

Receipts.—A sum of Rupees (1,348-13-0) one thousand and three hundred and forty-eight and annas thirteen only was realized from the sale of improved seeds, etc., and credited to Government during the financial year ending 31st March 1935.

TRAINING

Post-graduate Training.—Messrs. Sarvayya Chetti, Pushkar Nath, Abdul Aziz, M. P. Bhatnagar, and S. V. A. Hydari completed their post-graduate training during the year and were of material help in the investigations with which they were concerned. On completion of their courses Messrs. Pushkar Nath and Abdul Aziz worked in the Section as honorary research workers from November 1934 to March 1935.

Messrs. P. Krishna Rao, Parlakimedi Scholar from Madras, S. B. Vaidya, King Edward Scholar from the Central Provinces,

S. Z. Hasanain and A. K. Paul, private students from the United Provinces and Bengal, respectively, continued to receive training.

Messrs. R. K. Tandon, and A. K. Mallik from the United Provinces and S. D. Misra from the Central Provinces were admitted this year.

All the post-graduate students were sent to Karnal for a week in March 1935, in order to study the growth and behaviour of crops under irrigated conditions.

As in the previous year, students from the Chemical, Entomological and Agricultural Sections also attended the course of lectures delivered in this Section on Biometry and Statistics during the year.

Dr. J. K. Dubey, Director of Agriculture, Bhopal State, was given special training in plant breeding, Biometry and laboratory technique from November 1934 to February 1935.

Short-Course in Flue-curing Tobacco.—The following ten students were given a special two months' course which consisted of lectures as well as practical training in flue-curing of tobacco :—

- | | |
|--------------------------------|-----------------------|
| 1. U San Maung | (Burma). |
| 2. Mr. Inam Ahmad | } (United Provinces). |
| 3. „ H. S. Gupta | |
| 4. „ S. K. Shrivastava | |
| 5. „ R. Dittamal | (Punjab). |
| 6. „ P. Gopalaratnam | (Madras). |
| 7. „ J. K. Banerji | } (Bihar and Orissa). |
| 8. „ L. N. Chowdhry | |
| 9. „ R. S. Patil | |
| 10. „ Sarvottam Rao | (Hyderabad State). |

The first eight students were deputed by Provincial Agricultural Departments and the last two by States.

Dairy Students, etc.—Three Dairy Course students, Messrs. Jadhava, Ekambaram, and Perera were given a short course of lectures on plant breeding and field statistics during January, 1935.

Three Assistant Marketing Officers spent a week in this section in February 1935 and were given all possible help in their respective subjects. One Senior Marketing Officer also spent a day in the section.

SEASON AND RAINFALL

The total annual rainfall fell below the average for the 25-year period 1906-1930, by 6.32 inches. The month of July received an unusually large share of the total annual precipitation but most of the other months received slightly less rain than the average. The year was remarkable for the unusually high incidence of virus diseases. The tobacco crop sustained the most severe attack of

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"leaf curl" yet recorded in this section, and a field of sann-hemp grown for seed purposes was rendered entirely valueless owing to the attack by a virus disease which almost completely inhibited flowering and seed-setting. Virus diseases were also noted in sesamum, chillies, etc.

A statement of rainfall in the Botanical Section in 1934-35 is given below :

Statement of rainfall in the Botanical Section in 1934-35

Month		Average for 25 years (1906-30)	From 1st June 1934 to 31st May 1935	Difference
		Inches		
June	1934	7.53	6.95	-0.58
July	"	11.08	16.27	+5.19
August	"	14.09	8.41	-5.68
September	"	8.05	4.55	-3.50
October	"	1.81	2.89	+1.08
November	"	0.43	0.35	-0.08
December	"	0.18	0.00	-0.18
January	1935	0.34	0.24	-0.10
February	"	0.68	0.62	-0.06
March	"	0.41	0.00	(Traces) -0.41
April	"	0.56	0.00	" -0.56
May	"	1.44	0.00	" -1.44
Total		46.60	40.28	-6.32

Statement showing the seed distribution in 1934-35 of improved varieties of crops evolved in the Botanical Section, Pusa

Crops	Quantity	Remarks	Crops	Quantity	Remarks
	Lbs. oz.			Lbs. oz.	
<i>Barley Types</i>			<i>Gram Types</i>		
Type 1	1 0		Type 2	61 0	
" 2	10 0		" 6	66 0	
" 7	20 0		" 9	0 2	
" 10	1 0		" 17	435 8	
" 12	1 0		" 25	568 8	
" 13	1 0		" 28	252 0	
" 14	21 0		" 53	17 0	
" 16	1 0		" 54	17 0	
" 17	10 0		" 58	1,076 4	
" 20	11 0		" 67	17 0	
" 21	4,684 0		<i>Ganja Seed</i>		
" 22	14 0		Type 1	123 2	
" 23	12 0		Mixed	41 0	
" 24	8 0		<i>Linseed Types</i>		
<i>Chillies Types</i>			Type 12	115 2	
Type 34	3 2		" 121	153 0	
" 41	0 8		" 124	25 12	
" 46	1 0		Hybrid 10	26 0	
" 51	0 14		" 21	77 12	
			" 55	115 12	
			" 63	41 0	
			" 68	64 0	

Crops	Quantity	Remarks	Crops.	Quantity	Remarks.
	Lbs. oz.			Lbs. ozs.	
<i>Lentil Types</i>			<i>Rahar Types</i>		
Type 3	2 0		Type 5	4 8	
" 11	24 0		" 15	26 0	
" 47	6 0		" 16	21 0	
" III-54	49 0		" 24	544 0	
" III-86	93 0		" 51	55 0	
<i>Mung Types</i>			" 64	44 0	
Type 18	12 0		" 80	44 10	
" 23	10 0		" 82	101 4	
" 81	10 0		<i>Sarsan Seed</i>		
" 36	12 0			2 0	
<i>Oats</i>			<i>Safflower Types</i>		
B. S. 1	548 0		Type 1	30 0	
" 2	106 0		" 2	30 0	
Hybrid C	86 0		" 3	0 8	
" G	37 0		" 7	32 0	
" J	69 0		" 8	1 0	
<i>Patwa Types</i>			" 14	0 4	
Type 3	51 2		" 22	1 0	
" 6	41 3		" 25	30 0	
New Patwa	44 1		" 30	10 0	
<i>Paddy Types</i>			<i>Sesamum Types</i>		
Type 9	6 8		Type 3	6 4	
" 18	105 0		" 7	6 4	
" 24	162 2		<i>Tobacco Types</i>		
" 31	166 12		Type 28	5 9	
" 52	293 0		" 18 (New Rustica)	3 13	
<i>Peas Type</i>			Hybrid 142	2 5	
Type 29	256 4		" 177	4 3	
<i>Potato Varieties</i>			Adcock	1 14	
Pusa white	36 0		<i>Wheat Types</i>		
Darjeeling variety	82 0		Pusa 4	903 4	
<i>Rai seed</i>			" 12	527 4	
	2 0		" 52	4,828 4	
			" 80-5	709 4	
			" 101	1,417 10	
			" 111	581 4	
			" 114	299 12	
			" 122	12 0	
			" 125	12 0	
			" 165	0 2	

II. INVESTIGATIONS

WHEAT (*Triticum vulgare* Host.)

Rust attack and lodging due to strong winds and rain in February were mainly responsible for the fact that only average yields were obtained from wheat fields which promised heavy crops earlier in the season. The highest yielders were Pusa 52 which grown on an area of 0.78 acre yielded 2148.7 lbs. of grain per acre and Pusa 80-5 which grown on an area of 0.34 acre gave an outturn of 1913.5 lbs. of grain per acre. The bushel weights are given in Table I. It will be noted that bushel weights with two exceptions, were higher this year as compared with those for the last year. They were also higher than the average for the last 6 years.

TABLE I

Showing bushel weights of some Pusa wheats

Variety	Weight per bushel in lbs.		
	Average for the past six years ending 1932-33	1933-34	1934-35
Pusa 4	64.23	64.36	64.90
Pusa 12	61.77	59.76	62.80
Pusa 52	64.72	65.67	65.31
Pusa 80-5 . . . . .	..	..	64.50
Pusa 101 . . . . .	..	65.77	65.95
Pusa 111 . . . . .	..	64.58	63.50

Good reports on Pusa wheats were received from various localities. Pusa 4 has been found to be one of the most promising varieties tried in the Nizam's Dominions. Pusa 111, as well as Pusa 80-5 and Pusa 165 have been a success in the United Provinces as is indicated by the Report of the Department of Agriculture in the United Provinces, published in 1935. The Report states "In the trials conducted by Economic Botanist at Raya and Cawnpore, Pusa 165, Pusa 111 and Pusa 80-5 were shown to be of distinct merit over others, Pusa 165 standing best of all". Pusa 114 has continued to be so successful in Sind that the Agricultural Department has issued a leaflet (Agricultural Leaflet No. 38, 1934) entitled "The Advantages of the cultivation of Pusa 114 wheat in Sind". The main advantages to which attention is drawn are the heavy yield, early maturity, rust resistance and high grain quality of this variety. As it is an awned wheat it is especially suitable for cultivation in tracts where there is danger of damage by birds or wild animals.

As mentioned in the last annual report of this Section, two promising hybrids, Pusa 165 and Pusa 120, obtained by crossing the Australian variety Federation with Pusa 4 and Pusa 52, respectively, were tried against the established Pusa wheats and the best wheats bred by the Provinces concerned at a number of stations in the United Provinces and the Punjab in 1933-34. The result was the outstanding success of Pusa 165 which occupied the first three places 14 times out of 18 trials. In the United Provinces and the eastern Punjab to which it appears to be particularly well suited, Pusa 165 has almost invariably outyielded the best local varieties and the established Pusa types. Pusa 120 did not have the same striking success although it did well at a number of places. The trials with these two wheats were also repeated this year but

the results are not yet available. Yield trials with other promising Federation hybrids were carried out for the third year, and, according to the results of their performances, two hybrids have been selected for more extensive tests.

The yield trials of Pusa 52 *versus* a local wheat obtained from the Deputy Director of Agriculture, Muzafferpur, were repeated for the third year in succession, and for the third time again Pusa 52 significantly outyielded the Muzafferpur local variety. The superiority of Pusa 52 having been certainly established, the yield trials will now be discontinued.

As mentioned in Section I of this report, the breeding of rust-resistant wheats for India has been taken up with the collaboration of Dr. K. C. Mehta of Agra College, Agra. A note on this scheme will be found elsewhere.

BARLEY (*Hordeum vulgare* L.)

Investigations on the mode of inheritance of a number of characters in barley were continued. It has been observed that internal anatomical characters may, like external characters, be controlled by Mendelian factors. Thus in a cross between two Pusa barleys, *viz.*, T. 21 (non-lodging) and T. 1 (lodging), two genetic factors appeared to control the degree of development as well as the distribution and the thickness of the sclerenchyma. This was also confirmed by the behaviour of the F_2 plants in another cross, *viz.*, Cawnpur 251 \times Pusa T. 1; the latter (T. 1) being the common lodging parent in both crosses. A paper on this subject was read before the Calcutta Session of the Indian Science Congress in January 1935, and has been submitted for publication in the Indian Journal of Agricultural Science.

The nature of mechanical tissue in all the twenty-four types of Pusa barleys was studied. Four kinds of mechanical tissues, depending on the nature and extent of development of the sclerenchyma, were recognized and the Pusa barleys placed within the following categories:—

Mechanical tissue weakly developed (LODGING).—Types 1, 3, 4, 5, 15, 17 and 24. (Types 5, 17 and 24, however, have a greater number of layers of sclerenchymatous tissue than T. 1).

Mechanical tissue somewhat better developed than above. Intermediate—A. (PARTIALLY LODGING).—Types 10 and 19.

Mechanical tissue fairly well developed. Intermediate—B. (SLIGHTLY LODGING).—Types 6, 8, 9, 14 and 18.

Mechanical tissue very well developed. (NON-LODGING).—Types 2, 7, 11, 12, 13, 16, 20, 21, 22 and 23.

Striped and virescent plants in barley are being studied and some material has been fixed to study the cytology of albino, striped and virescent plants as well as of branched ears. Traces of both covered and loose smut appeared in T. 21 barley raised from untreated seed and sown about a month later than the usual date, in one particular plot, viz., Barah 4. In other plots, however, only a very few plants of this variety were affected with this disease. The attack of *Helminthosporium sativum* on the 24 types of Pusa barleys was less than that of last year and *H. teres* failed to make its appearance altogether. An investigation carried out at Pusa for the past four years, in collaboration with Dr. Mitra, Assistant Mycologist, Pusa, has shown that environmental factors play a great part in bringing about the disease caused by these two organisms and that the severity of the disease may vary from field to field and even in different parts of the same field. The percentage of leaf area destroyed in the various varieties was determined and the data statistically examined. In both the introduced and in the Pusa varieties of barley, types showing considerable resistance have been noted and promising selections from this view point have been made. A paper on this subject was read before the Indian Science Congress at Calcutta and has been accepted for publication in the Indian Journal of Agricultural Science.

Eight types of Pusa barleys were sent through the Bihar Department of Agriculture to Rothamsted for preliminary malting tests. The cost of the trial is being met by the Imperial Council of Agricultural Research and barleys from different tracts of Bihar have also been sent along with the Pusa types. The results are awaited. These same types will again be despatched to England in 1935-36. The eight types of Pusa barleys sent to Rothamsted last year together with six other types were also sent to the Imperial Agricultural Chemist, Pusa, for a preliminary malting trial and the results obtained will be reported by him.

The various types of Pusa barley have been observed to be attacked, in the seedling stage, by white-ants in different degrees of severity, the amount of damage done being particularly large in the highest yielding variety, viz., T. 21. Seeds and seedlings of this type and of Types 2 and 22 were analysed by the Imperial Agricultural Chemist who found that Types 21 and 22 yielded higher amounts of sugar than Type 2 which is usually attacked the least. Further analysis revealed that the seeds of Type 21 contained the least amounts of ash and silica and it seems possible that the relatively small amount of silica and the consequent softness of the tissues may have rendered seedlings of Type 21 more liable to white-ant attack.

OATS (*Avena sterilis* L. var. *culta* and *Avena* sp.)

The study of inheritance of certain qualitative and quantitative characters was continued. A number of very promising

hybrids have now been secured and will be subjected to yield tests. Of a number of new varieties imported this year from abroad, Fulghum from America, and Belar, Gidgee and Laggan from Australia, show some promise under Pusa conditions. A high degree of sterility, however, was observed in most of the exotic varieties of oats. A study of the average percentage sterility in these as well as in all Pusa oats has been made.

Covered smut is often found in Indian oats and varietal resistance of Pusa oats to this disease has been the subject of an investigation extending over a number of years. A detailed study was undertaken during the year with the collaboration of Dr. Mundkur of the Mycological Section and thirty differentials obtained from Reed in America and eight differentials obtained from Sampson in Wales for the purpose of identifying the physiological strains of the Indian smuts. These samples of oats included a number of species of oats, viz., *A. sativa*, *A. orientalis*, *A. sterilis*, *A. byzantina*, *A. strigosa*, *A. brevis*, *A. nuda*, *A. fatua*, etc. Sixty Pusa types and hybrids and the thirty differentials received from Reed were dehulled and infected with spores of *Ustilago kollerii* collected in the previous year, and were sown in replicated plots. All the types of oats, however, failed to develop covered smut, possibly due to the spores having already lost their viability. Since such spores have been known to remain viable in Great Britain and America for seven years or more the longevity of Indian smut spores is being studied further in the Mycological Section.

A paper on serial experiments with oats was read before the Indian Science Congress.

PADDY (*Oryza sativa* L.)

Preliminary yield trials were carried out with early (autumn) and late (winter) paddies. In the former, four types were tested against one another, and Type 124 and Type 18 were found to be the best. In the late paddy yield trial, eight Pusa types were tested against two selections from Sabour sent by the Paddy Specialist, Bihar and Orissa. The latter varieties, however, did not do very well under Pusa conditions and were very severely attacked by *Helminthosporium*. Among the Pusa types, Type 31 stood first.

Observations on chlorophyll deficient plants were commenced and detailed records of the life-histories of a number of such plants found in the nurseries were kept. An experiment to study tillering in two varieties of paddy with particular reference to the 'critical period of tillering' was initiated and weekly counts of tillering were taken. Both the investigations are being continued.

MAIZE (*Zea mays* L.)

Cultures were grown from about six hundred samples of cobs which were collected from different parts of India. Attempts were

made to study the morphological and economically important characters of all the cultures. All the cultures were of the flint type and the chief groups as regards seed colour were white, yellow and orange. The cultures differed markedly in characters such as maturity, plant height, cob size, seed size and grain yield. Some cultures appeared promising for grain yield and others for fodder, and all these have been selected for growing next year.

Inbreeding was continued with the strains from the previous year and some crosses were made between the selfed lines.

PIGEON-PEA (*Cajanus indicus* Spreng.)

A paper embodying the results of previous studies on the inheritance of morphological characters and of wilt-resistance in a cross between types 5 and 80 has been written and sent for publication. The mode of inheritance of a number of morphological characters has also been studied in a cross between Pusa Types 5 and 66.

A yield trial with eleven types of Pusa *rahars* was conducted on the Pusa Farm and types 64, 24, and 15 occupied the first three places as regards yield, but the differences between their mean yields were not statistically significant. Some hybrids combining wilt-resistance with erect habit have been fixed and their seed is being multiplied for yield tests.

Indications were obtained on a previous occasion that the severity of wilt (*Fusarium*) attack in pigeon-peas may be greatly retarded if the crop is grown in fields which had been under tobacco in the preceding season. This fact has been substantiated this year by an experiment in which a set of four lysimeters filled with soil from a tobacco field delayed the incidence of wilt to a much longer period than another set of lysimeters filled with soil from an adjacent linseed field. Type 5 *rahar* which is very susceptible to wilt was sown in all the lysimeters and the latter were infected artificially with *Fusarium* spore material. Weekly observations of the number of plants that died due to wilt during the period were maintained from the fourth to the thirty-first week after infection. Although most of the plants died in both the series owing to very heavy artificial wilt-infection of the soil, plants in the tobacco soil series took on an average 21.187 ± 0.348 weeks to die out, whereas those in the linseed soil series died in 17.548 ± 0.504 weeks. The difference of 3.639 weeks between the two series being statistically significant it was concluded that the toxic effect of tobacco stumps in the tobacco soil series helped to retard deaths due to wilt to a considerably longer period. It is possible that under ordinary conditions the rotation of pigeon-pea with tobacco may considerably lessen damage due to wilt.

✓ GRAM (*Cicer arietinum* L.)

The yield trial of eight types was repeated, and Type 53 and Type 58 occupied the first two places this year. It has now been

proved that the new types Nos. 53, 55 and 58 are definitely high yielders and worthy of trial on outside farms with the old established types Nos. 3, 17 and 25.

The progenies of two "stray" plants found last year in the types were studied. These were found to be segregating. In the progeny of the "stray" plant found in Type 79 (itself a mutant) it was interesting to find segregation to the ordinary and the gigantic form (like Type 79), the latter behaving as a simple recessive character.

PEAS (*Pisum sativum* L. and *P. arvense* L.)

The yield trial of five types was repeated and the *sativum* variety Type 29 found to be the best yielder as in the past two years.

Final observations on the types were made. The classification and description of these types is in preparation.

LENTILS (*Ervum lens* L.)

Six hybrid lentils were again tried this year against two very high yielding selections in a 8×8 Latin square. This experiment will be repeated once again and final results computed on the basis of the combined results of three years. The study of the inheritance of flower and seed colours in a number of crosses has been completed.

URID AND MUNG (*Phaseolus Mungo* L. and *P. radiatus* L.).

Preliminary yield trials with promising types of *urid* and *mung* were conducted. The mode of inheritance of a number of characters was studied in a cross between a green-seeded and a yellow-seeded *mung*. The results will be tabulated and written up for publication at an early date.

SUNN-HEMP (*Crotalaria juncea* L.)

Notes on morphological and economically important characters of single plant cultures were taken. A large number of these cultures were raised from single plant seed collected from different parts of Bengal and work has been started in collaboration with the Assistant Fibre Expert, in charge of the Fibre Section, Dacca, with the object of evolving strains of sunn-hemp suitable for Bengal.

A virulent virus disease attacked the sunn-hemp crop grown for seed purposes and later on spread to other single plant cultures which were grown away from the former. The different cultures, however, showed varying degrees of susceptibility to the disease.

A study of the root system of sunn-hemp has been made and the results agree very closely with those obtained in the previous year.

INDIAN HEMP (*Cannabis sativa* L.)

Three strains of Indian hemp (*ganja*) have finally been isolated.. Types 1 and 2 are good for *ganja* production, the former giving high yields and the latter producing drug of a superior quality. Type 3, on the other hand, is a tall growing strain, not suitable for *ganja* production and is being maintained only because it throws out the least number of monoecious plants and may thus be of some use in sex-studies. A quantity of *ganja* (about 123 lbs.) was cured and sold to the Excise Department, Bihar and Orissa. A smoking test was held by the Superintendent of Excise, Patna, who reports that veteran smokers were invited to smoke *ganja* obtained from Bhagalpur as well as that from Pusa and the smokers who were independently questioned spoke highly of the intoxicating effects of the Pusa *ganja* as compared to the Bhagalpur product. The Chemical Examiner for Excise, Bihar and Orissa, Patna, obtained the following analytical values for the mixed *ganja* sold to that Department.

	Per cent
Ash	14.9
Resin	12.0

"The sample of *ganja* is of fair quality. The physiological activity is about 3/4."

Three samples of *ganja* were also sent to the Imperial Agricultural Chemist, Pusa, for analyses and the following results were kindly furnished by him :—

Lab. No. of 1935	Particulars of sample	Extraction by carbon tetrachloride		Extraction by petroleum ether		Ash
		Specific rotation	Resin	Specific rotation	Resin	
			Per cent		Per cent	Per cent
87	Pusa Ganja, Cured Type 1-2.	—137.03	13.60	—143.28	11.76	17.3
88	Pusa Ganja, Cured Type 2-2.	—174.10	15.05	—203.80	13.56	15.3
89	Pusa Ganja, Cured Type 1 mixed.	—157.43	14.80	—148.17	13.44	15.1

TOBACCO (*Nicotiana tabacum* L. and *N. rustica* L.)

At least 50 per cent of the plants of Hybrid 142 cigarette tobacco grown for fine-curing were affected by "leaf-curl" disease. This high incidence, however, was favourable for the study of the disease.

which has been taken up with the collaboration of the Entomological Section.

Seed of Hybrid 142, Adcock and Harrison's Special was raised in large quantities for supply to the Provinces in connection with a co-operative scheme, financed by the Imperial Council of Agricultural Research, to determine what areas in India are suitable for the cultivation and curing of cigarette tobacco.

A few hybrid plants obtained from a cross between *N. tabacum* and *N. plumbaginifolia* are under study.

POTATO (*Solanum tuberosum* L.)

Work on this crop was begun in the year under review and the collection and study of material from different parts of India and from abroad was undertaken. The Imperial Council of Agricultural Research has approved of a scheme whereby potato breeding for Northern India will be carried out at Pusa (and subsequently at Delhi) and at a sub-station in the hills. A note on this scheme has been prepared by the Second Economic Botanist who is in charge of the scheme and appears elsewhere.

CHILLI (*Capicum annum* L. and *C. frutescens* L.)

The original fifty-two types were maintained. Some of the types of chillies from Goa which were found to be still segregating were discarded as well as those which were not promising from an economic point of view.

The F_1 of a cross between Type 1 and Type 2 was grown to study the inheritance of colour of unripe fruit which is green in the former and creamy in the latter. In F_1 the unripe fruit is green which indicates dominance of this colour over creamy. The F_2 of Type 29 \times Type 11 and the F_2 of Type 3 \times Type 11A were studied for the inheritance of anther colour. The yellow colour of anthers of Type 11A was found to be recessive to the deep purple and light purple anther colour of Types 3 and 29, respectively on a 3 : 1 basis. It was also observed that purple colour in anthers is linked with purple node colour in both Type 3 and Type 29.

HIBISCUS (*Hibiscus sabdariffa* L. and *H. cannabinus* L.)

The F_2 's of the crosses between varieties Albus and Ruber and between Ruber and New Hibiscus were grown to study the effect of time of fertilisation of F_1 plants on the phenotypic segregation in F_2 . Populations of about 12,000 in the case of the former cross and about 22,000 in the case of the latter were grown. The results did not indicate that the age of F_1 plants has any influence on the phenotypic segregation in F_2 . The results, therefore, confirm the observations of the previous year when the populations studied were comparatively much smaller.

A cross between two very early varieties of *H. cannabinus* L. one with white corolla and the other with yellow corolla was made and the F_1 grown the same year. The corolla in F_1 was yellow indicating its dominance over white.

The F_2 of a cross between an early, short variety and a late, tall variety of *H. cannabinus* L. was grown to study the inheritance of (a) number of days required for flowering and (b) height of plant. The results indicate that probably a number of cumulative factors determine each of the characters. The F_2 is expected to throw more light on this. The original types were maintained.

LINSEED (*Linum usitatissimum* L.)

In connection with the attempt to breed out flower colour factors a very large F_2 population of the cross between a white and a pink flowered variety was grown with the expectation of realizing a genotype in which all colour (petal) factors would be absent and which could be used as a "tester". About 200 single plants from the phenotype with white petals and white anthers in F_2 were each crossed with four different types of known genetic constitution. The progenies out of these crosses are expected to indicate if any of these 200 plants lack all the colour factors. The seed colour of these 200 plants is either brown, fawn, grey or yellow and as some of the seed colour factors also influence petal colour, the elimination of plants with certain seed colours is expected to facilitate the isolation of the desired genotype.

The F_3 generations of two crosses, Type 12 \times Type 24 and Type 21 \times Type 24, confirmed the dihybrid segregations for petal colour observed in F_2 , and the study is expected to elucidate the genetic constitution of Type 24.

The F_1 generations of crosses between rust-resistant and rust-susceptible types were grown. No trace of rust was observed on the F_1 s while the rust-susceptible parents and other adjoining cultures were attacked indicating dominance of rust-resistance over susceptibility to rust.

Yield trials of seven hybrids against the standard type 12 were repeated for the third time. Type 12 has consistently proved superior in yield to all the hybrids except Hybrid 21 and Hybrid 55 in one year when it was equal to these hybrids. Hybrid 55 which fared well in the two previous years went down in yield very much and Hybrid 68 took its place. It seems that in dry years and in tracts of low rainfall Hybrid 68 out-yields Hybrid 55 probably because of its earlier maturity. The reports of yield trials conducted by some of the Provincial Agricultural Departments also show Hybrid 68 to be very promising.

Retting experiments with ordinary linseeds were carried out and a sample of fibre of Type 124 was sent to the Imperial Institute, London, for opinion. The preliminary tests indicate that

the fibre though coarse may find a good market in England. Large quantities of the fibre, however, are required for detailed tests and as it is not possible to supply these the investigation will unfortunately have to be dropped. The interesting fact remains, however, that the ordinary linseed is capable of yielding good fibre.

The seed-weight and size (volume) of all the types and hybrids of linseed were determined. There is indication that a negative correlation subsists between seed size and oil percentage, this being contrary to the general belief that the larger the seed the higher the oil content. While trying to correlate seed size and oil percentage a few other interesting points were discovered. Thus seeds of the brown seeded hybrids were found to be, on the whole, the heaviest and largest, and contained the lowest oil percentage. Next came the gray seeded hybrids, closely followed by the fawn seeded ones. The yellow seeded hybrids were, on the whole, the lightest and the smallest in size but possessed the highest oil-content. The oil-content, therefore, appears to increase with increasing lightness of seed colour as well as with decrease in seed size. The data are being further analysed.

SAFFLOWER (*Carthamus tinctorius* L.)

The various types were maintained. The F_1 of a cross between Type 27 and a chlorotic mutant disclosed the normal green condition to be dominant to the chlorotic condition.

The F_2 's of a number of crosses were studied for the inheritance of flower colour, spininess and bract-shape.

White flower was found to be recessive to yellow or orange flower on a 3 : 1 basis. The spineless character was found to be recessive to its allelomorph on a 15 : 1 basis and roundish shape of bract recessive to elongate shape on a 3 : 1 ratio.

SESAMUM (*Sesamum indicum* DC.)

Owing to heavy rains at sowing time germination was rather poor but growth was more vigorous than in the preceding year.

The influence of time of sowing on yield was studied and it was discovered that the earlier sown series heavily out-yielded the later-sown series. Certain F_1 's from crosses between the Pusa types of sesamum were studied to see whether there is any hybrid vigour in this crop.

Phyllody, which assumes serious proportions in certain years causing loss in yield owing to decreased seed-setting in phylloid plants, was also under investigation, and the data so far obtained indicate that it is probably of the nature of a virus disease.

BRASSICAE

Observations on the types were made and the tentative classifications of the different groups finally checked. A paper on this subject is being written up for publication.

A type of *rai* (*B. juncea*, Hooker) with lyrate leaves and other kinds of *rai* with non-lyrate leaves were crossed last year to study how these kinds of *rai* are related to each other. The F_1 generations of these crosses were grown this year and almost all crosses were found to have been successful and showed a marked degree of hybrid vigour. Observations on different morphological characters were recorded on these hybrids.

The F_2 families of a cross between two types of *rai* were studied for pod habit and last year's results with F_2 populations confirmed.

The F_2 families of a cross between two types of yellow *sarson* (*B. campestris* var. *Sarson*, Prain) were also studied for flower colour and number of pod valves.

The inheritance of self fertility was studied in the F_4 families of a cross between yellow *sarson* (self-fertile) and black *sarson* (self-sterile). The mode of inheritance of this character appears to be very complex.

Statement of yield of crops in the Botanical Section, Pusa, during 1934-35

Crop	Plot	Area in acres	OUTTURN OF GRAIN IN POUNDS		Remarks
			Actual	Per acre	
<i>Wheat—</i>					
P. 4 .	Orch. 3-A . . .	0.55	550.8	1,001.5	Sown very late without ma- nure.
P. 12 .	N. T. G. 3 . . .	0.36	566.2	1,572.8	No manure.
P. 52 .	Pentagonal . . .	4.22	7,239.6	1,715.5	Ferm. cake 50 Mds.
P. 52 .	Mush. Out No. 2 . .	0.20	325.0	1,625.0	Ferm. cake 2 Mds.
P. 52 .	Mush. Out No. 3 . .	0.20	337.9	1,689.5	Ferm. cake 2 Mds.
P. 52 .	N. T. G. 10 . . .	0.78	1,676.0	2,148.7	Ferm. cake 15 Mds.
P. 80.5 .	Lawn 3	0.34	650.6	1,913.5	Ferm. cake 8 Mds.
P. 101 .	N. T. G. 10 . . .	1.0	1,820.0	1,820.0	Ferm. cake 20 Mds.
P. 111 .	Orch. 3-B	0.54	475.2	880.0	Sown very late, with o u t manure.

Crop	Plot	Area in acres	OUTTURN OF GRAIN IN POUNDS		Remarks
			Actual	Per acre	
Barley—					
Type 21	River bank west	0.74	2,575.6	3,480.5	Manured with Ferm. cake & Mds.
"	Oroh. 4-A	0.65	1,375.2	2,115.7	No manure.
"	Barah 4	0.75	1,769.1	2,358.8	Sown late after removing sesa- mum crop.
"	Mush. Out No. 5	0.20	485.5	2,427.5	Sown late after removing Urid crop. No manure.
Oats—					
B. S. 1	Farm 1	0.43	643.9	1,497.4	No manure.
B. S. 2	Farm 1	0.42	497.8	1,185.2	No manure.
Hybrid C	River bank east	0.38	927.8	2,441.6	Manured with ferm. cake 4 Mds.
Hybrid J	River bank east	0.38	1,055.3	2,777.1	Manured with ferm. cake 4 Mds.
Hybrid G	N. T. G. 1	0.21	436.1	2,076.7	No manure.
Paddy—					
T. 9	Gonhri border	0.05	40.1	802.3	
T. 18	" Plot No. 1	0.16	366.2	2,287.5	
T. 24	" " 2	0.16	323.0	2,018.6	
T. 24	" " 11	0.16	298.3	1,864.3	
T. 31	" Triangular plot	0.53	972.0	1,494.3	
T. 52	" Plot No. 3	0.16	298.3	1,864.3	
T. 52	" " 10	0.16	240.7	1,504.3	
Lentils—					
III-86	S. T. G. 1	0.02	20.6	1,030.0	No manure.
"	" 7	0.04	47.3	1,182.5	"
"	" 9	0.05	45.3	906.0	"
Ganja (In- dian nemp)—					
Type 1	Barah 5	0.47	142.9	304.0	Manured with 20 srs. Ammon. sulphate.
" 2	N. T. G. 4	0.08	42.1	526.2	Manured with 10 srs. Ammon. phos. and F. Y. manure 5 carts.
			Yield of drug in lbs.		
Cured Ganja	" 4	0.25	123.45	493.8	
Linseed—					
T. 12	Barah 2 and 3 parts	0.15	138.7	918.7	
T. 12	Pent. E. border	0.11	80.2	729.1	
T. 124	Mush. out No. 1	0.20	111.6	558.0	
T. 121	Pent. W.	0.13	126.0	969.2	
H. 55	Mush. out No. 4	0.20	67.9	339.5	
Safflower—					
T. 30	Barah 7 and 8 parts	0.10	50.4	504.0	

Crop	Plot	Area in acres	OUTTURN OF GRAIN IN POUNDS		Remarks
			Actual	Per acre	
<i>Gram—</i>					
T. 2 .	Orch. 6 B part .	0.17	133.7	786.5	
T. 6 .	" " .	0.20	308.6	1,543.0	
T. 17 .	" 6 A part .	0.78	1,388.6	1,780.3	
T. 25 .	" " .	0.78	1,197.3	1,535.0	
T. 28 .	" 6 B part .	0.25	425.8	1,703.2	
T. 58 .	" " .	0.80	1,845.2	2,306.6	
<i>Peas—</i>					
S. 14-1 .	S. T. G. 5 .	0.16	186.10	1,163.1	

Statement showing the outturn of improved varieties of crop from the Botanical Section grown at the Pusa Farm during 1934-35

Crop	Plot	Area in acres	OUTTURN OF GRAIN IN POUNDS	
			Actual	Per acre
<i>Barley—</i>				
T. 21 . .	3, 4, 7, 8, 11, 12, 15, 16 Punjab D Block .	2.00	2,037.60	1,018.80
T. 21 . .	North Pangarbi .	5.75	12,054.80	2,096.49
<i>Oats—</i>				
B. S. 2 . .	Brickfield 2 . .	2.00	1,992.80	996.40
Hybrid J . .	" . .	6.00	5,428.80	904.80
" C . .	" . .	3.00	1,890.50	630.17
<i>Rahar—</i>				
T. 15 . .	Bhugrason . .	5.00	6,128.20	1,025.60
T. 24 . .	" . .	9.00	11,139.50	1,237.70
T. 51 . .	" . .	9.10	7,792.50	855.10
T. 80 . .	" . .	4.40	3,404.60	773.77
<i>Safflower—</i>				
T. 1 . .	28 D, Punjab D Block	.0625	70.40	1,126.40
T. 2 . .	" " "	.0625	45.80	732.80
T. 3 . .	" " "	.0625	40.10	641.60
T. 4 . .	" " "	.0625	61.20	979.20
<i>Hibiscus (Patwa)—</i>				
Type 3 . .	Nepali . .	.50	52.40	104.80
" 6 . .	" . .	.50	83.30	166.60
New Patwa seed .	" . .	.10	29.80	298.00
" fibre .	" . .	.50	59.70	119.40

III. PUBLICATIONS AND PROGRAMME OF WORK FOR 1935-36

List of papers published during 1934-35

1. Kashi Ram and Ch. V. Sarvayya Chetty The Classification of Rices of Bihar and Orissa. *Ind. Jour. Agri. Sci.*, Vol. IV, pt. IV, 1934, pp. 618-641.
2. ————— Development of Pigments in the Glumes and Apiculus of Rice Varieties. *Ind. Jour. Agri. Sci.*, Vol. IV, pt. IV, 1934, pp. 642-655.
3. Pal, B. P. Recent Progress in Plant Breeding at Pusa. *Agri. and Livestock*, Vol. IV, pt. V, 1934, pp. 505-515.
4. ————— Wheat Rusts from the view point of Plant Breeding (Paper read at the Symposium on Cereal Rusts at a Joint meeting of the Botanical and Agricultural Sections of the Indian Science Congress, Calcutta, Jany. 1935). *Agri. and Livestock in Ind.*, Vol. V, pt. II, 1935, pp. 139-144.
- 5 Shaw, F. J. F. and Kashi Ram Improved Varieties of Crops Produced at Pusa. *Agri. and Livestock in India*, Vol. IV, pt. V, 1934, pp. 465-480.
6. Shaw, F. J. F. Indian Agriculture and Plant Breeding. (Presidential Address to the Agricultural Section of the Indian Science Congress, Calcutta, Jany. 1935, pp 109-114).

PROGRAMME OF WORK FOR 1935-36

Work will be continued on the breeding and genetics of those crops which have formed the subject of this report. Special attention will be given to yield trials and statistical methods.

Training of students will continue as in past years.

(2) BOTANICAL SUB-STATION, KARNAL**I. INTRODUCTION**

Mr. Kashi Ram held the post of Superintendent up to May 24, 1935, when he reverted to the post of Assistant Economic Botanist, Imperial Institute of Agricultural Research, Delhi. Mr. Hukam Singh, Assistant to the Imperial Economic Botanist, Pusa, took charge from May 25, 1935.

Rulya Ram, Head Mali, was transferred to the "Lay Out" section of the Imperial Institute of Agricultural Research, Delhi. Thaggan, Assistant Mali, Botanical Section, Pusa, was appointed to officiate in place of Rulya Ram from May 23, 1935. Tale Ram, Watchman, was also transferred to the "Lay Out" Section, Delhi.

During this year the following amounts were realised, principally by the sale of seeds :—

	Rs.	A.	P.
(1) Cash credited into Karnal Treasury . . .	1,770	7	0
(2) Receipts adjusted by Book Transfer . . .	388	7	6
Total . . .	2,158	14	6

LAY-OUT AND CONSTRUCTION

A block of about 18 acres, in the General Area was levelled in the last cold weather. Another block of about 20 acres will be taken up for levelling during the ensuing year. The levelling of roads in the General Area was continued and two more roads have been levelled. Some more roads, however, still remain to be levelled up.

The following areas have been fenced with Hercules woven wire fencing :—

- (1) Building area.
- (2) Experimental area.
- (3) Rice area.

TRAINING

A batch of eight post-graduate students from the Botanical and Agricultural Sections, Pusa, visited the Sub-station in March 1935 to observe farming and plant breeding under irrigated conditions. Students from the Agricultural College, Lyallpur, were also shown the work in progress at the Sub-station.

VISITORS

Mr. Ramdhan Singh, Cerealist to Government, Punjab, and Mr. Nand Singh, Extra Assistant Director of Agriculture, Karnal, visited the Sub-station in March 1935.

Mr. Livingstone, Agricultural Marketing Adviser to the Government of India and Mr. Javarayya, Senior Marketing Officer, visited the Sub-station in April 1935.

SEASON AND RAINFALL

The season was characterised by heavy downpours in the months of July and August followed by a drought in September. Continuous cloudy weather with intermittent showers in April was very favourable for black rust which caused much damage to wheat.

Statement showing the rainfall at the Botanical Sub-station, Karnal, in 1934-35

Months	Rainfall inches	Number of cloudy days in the month
1934		
July	16.98	26
August	9.97	30
September	0.43	11
October . . . . .	..	..
November . . . . .	..	5
December	0.26	18
1935		
January	2.76	16
February	1.35	13
March	0.54	15
April	1.47	14
May . . . . .	..	6
June . . . . .	..	13
Total	33.76	167

II. INVESTIGATIONS

WHEAT (*Triticum vulgare* Host.)

As indicated in last year's annual report wheat hybrids P. 165 and P. 120 were subjected to extensive field tests in the Punjab and United Provinces against the well-known Pusa wheats and also the best wheats evolved by the Provinces concerned. The results obtained were statistically analysed and showed that in P. 165 we possess a wheat of distinct merit. Out of 18 yield trials, it stood first in 2 trials (the difference between P. 165 and the next best being statistically significant on four occasions), second in 3 cases and third in 3 cases. In the United Provinces and South East of Punjab it out-yielded the best local wheats and the established Pusa wheats. Pusa 120 did not, however, have the same success, perhaps owing to its grain-shedding character which reduces the final yield. Both hybrids 120 and 165 are characterised by good stand and comparative resistance to rusts.

These varietal trials have been repeated in the year under report in the Punjab and United Provinces. So far, the results from only

one station in the Punjab, Jullundur, where P. 165 again out-yielded the other wheats in the trial, giving a significantly higher yield than P. 120, P. 114, P. 111, P. 112, P. 80-5, Punjab 8-A and Punjab C. 409, both under irrigated and non-irrigated conditions, have been received. In the yield trial conducted this year at this Substation also P. 165 has proved to be superior to P. 120, P. 80-5, P. 114, Cawnpore 13, Punjab C. 591 and Punjab C. 518, the difference in yield between it and the other wheats mentioned being statistically significant. The full results are given in Table I.

TABLE I

Wheat yield trial (Varietal)

Comparison of wheats Pusa 80-5, 114, 120, 165, Cawnpore 13, and Punjab C. 518 and C. 591
Plan and yields of grain in lbs. per plot

O. 13 37.50	P. 114 40.75	P. 120 38.37	P. 80-5 44.31	P. 165 62.00	C. 518 44.81	C. 591 38.94	P. 114 42.19	C. 13 34.19	P. 120 35.00	C. 518 33.37	P. 80-5 39.12	P. 165 58.44	C. 591 36.12
P. 80-5 52.44	C. 591 41.31	P. 165 60.00	C. 518 37.06	P. 114 43.25	P. 120 49.69	C. 13 39.56	C. 518 49.81	P. 165 53.06	P. 80-5 43.25	P. 114 40.37	C. 591 36.00	C. 13 34.00	P. 120 40.69
C. 518 60.56	C. 13 37.87	P. 120 53.31	P. 165 61.19	C. 591 35.81	P. 80-5 50.25	P. 114 44.25	C. 518 43.94	P. 120 43.56	P. 165 59.12	C. 13 36.25	C. 591 39.25	P. 114 42.19	P. 80-5 31
P. 114 42.81	C. 591 45.81	C. 518 50.44	P. 120 50.62	C. 13 40.81	P. 165 59.00	P. 80-5 52.94	C. 13 36.19	P. 165 61.62	P. 114 45.00	C. 518 37.75	P. 80-5 47.00	P. 120 50	C. 591 06
C. 518 42.81	P. 80-5 56.25	C. 13 38.94	P. 165 59.06	C. 591 31.62	P. 114 40.56	P. 120 42.50	C. 591 36.31	P. 80-5 43.25	P. 120 48.50	C. 13 37.12	P. 114 44.87	P. 165 58	P. 80-5 55.75
P. 120 52.00	C. 518 50.56	P. 165 60.12	P. 114 44.75	C. 13 33.44	C. 591 38.00	P. 80-5 47.75	P. 165 57.12	C. 518 41.75	C. 13 37.50	P. 80-5 47.87	P. 114 46.75	P. 120 47.25	C. 591 44.94

System of replication—Randomized blocks (7 varieties and 12 replications).

Area of each plot—56' × 14' = 1/55-56th of an acre.

Seed sown on—4th November 1934.

Harvested on—17th April 1935.

Previous crop—Gram.

Summary of results (Grain)

	Mean yields in lbs.						General mean	Standard error of treatment mean	Whether general effect of treatment is significant by 'Z' test	Critical difference for significance in lbs. per acre
	P. 165	P. 120	P. 114	P. 80-5	Cawnpore 13	Punjab C. 591	Punjab C. 518			
Per acre	3270.82	2532.42	2396.86	2656.32	2052.94	2139.61	2470.20	2502.74	60.15	218.96194
Per cent. on General Mean.	130.69	101.19	95.78	106.14	82.03	85.50	93.71	100.00	..	..

- (1) P. 165 superior to P. 120, P. 80-5, P. 114, C. 518, C. 591, C. 13.
 (2) P. 80-5=P. 120=C. 518 but superior to P. 114, C. 591 and C. 13.
 (3) P. 120=C. 518=P. 114 but superior to C. 591 and C. 13.
 (4) C. 518=P. 114 but superior to C. 591 and C. 13.
 (5) P. 114 superior to C. 591 and C. 13.
 (6) C. 591=C. 13.

The differences are significant at 1 per cent level.

In addition to P. 120 and P. 165, other hybrids have also been selected and it is intended to give them a preliminary yield trial during the following year. The hybrids from the cross between Pusa 52 and Federation which were previously known as 13-1, 23-1, 52-1, and 61-1-2 are now numbered as P. 121, P. 123, P. 126 and P. 116, respectively. Of these P. 126 is very late. All these wheats are non-shedding, possess good standing power, and are relatively rust resistant.

As mentioned in the last year's annual report the experiment on wheat bunt was repeated by the Imperial Mycologist and the results are published in the Indian Journal of Agricultural Science (Vol. V, part I, pp. 51-74).

Seed Treatment

All the wheat seed of the last year as well as from this year's crop was treated against loose smut. Last year, two methods, solar heat treatment and the orthodox hot water treatment were employed but as the former was not so successful as the latter all the seed has been treated this year by the hot water method. In this connection, the help rendered by the Mycological Section at Pusa is gratefully acknowledged.

*BARLEY (*Hordeum vulgare* L.)*

A few new samples of barleys were grown along with selections from the crosses made at Pusa. Selections in these cultures have been made on the basis of good stand, white colour of grain, etc., and will be grown during the next year for further study.

Barley types 4, 13, 16, 18, 21 were again tried in a yield trial against Lyallpur types 4 and 5 in a 7×7 Latin Square. The results of this yield trial are given in Table II.

TABLE II

Barley yield trials (Varietal)

Comparison of Pusa types 13, 18, 4, 21 and 16 and Lyallpur types-
4 and 5.

Plan and yield in lbs. per plot.

T. 13 48·81	L. 5 55·94	T. 18 46·56	T. 4 37·62	L. 4 29·81	T. 21 55·44	T. 16 52·19
L. 4 42·44	T. 13 51·00	L. 5 60·06	T. 18 44·31	T. 16 54·81	T. 4 35·44	T. 21 68·94
T. 18 58·12	T. 4 48·69	T. 21 69·81	L. 4 37·94	T. 13 51·00	T. 16 61·44	L. 5 61·94
T. 21 60·06	T. 18 50·19	T. 4 45·06	T. 16 62·44	L. 5 58·44	L. 4 44·06	T. 13 61·94
L. 5 51·81	T. 16 60·00	T. 13 53·56	T. 21 67·19	T. 4 44·62	T. 18 51·31	L. 4 42·00
T. 16 43·94	T. 21 59·44	L. 4 42·81	T. 13 53·56	T. 18 46·81	L. 5 54·94	T. 4 41·81
T. 4 34·56	L. 4 37·31	T. 16 36·56	L. 5 44·81	T. 21 54·44	T. 13 49·31	T. 18 46·81

System of replication—Latin Squares (7 varieties and 7 replications).

Area of each working plot—49' × 15'—1/59·26 of an acre.

Sown on—30th October 1934.

Harvested on—4th April 1935.

Previous crop—Gram.

Summary of Results (Grain)

	Mean yield in lbs.						General mean	Standard error of treatment mean	Whether general effect of treatment is significant by "Z" test	Critical difference for significance in lbs. per acre
	T. 13	L. 5	T. 18	T. 4	L. 4	T. 21	T. 16			
Per acre	3125.37	3284.19	2913.22	2436.18	2339.58	3685.38	3143.74	102.3124	Significant	397.63 at 1 per cent level
Per cent on General mean.	104.54	109.85	97.44	81.48	78.26	123.27	105.15	..	..	..

Type 21 > L. 5 = T. 16 = T. 13 > T. 18 > T. 4 = L. 4.

OATS (*Avena sterilis* L. var. *culta*, etc.)

1.74 acres of the improved types were grown for multiplication. The yield of this crop has been shown in the outturn statement appended at the end.

PADDY (*Oryza sativa* L.)

The classification of types of rice isolated from samples collected from parts of the United Provinces and the Punjab has been completed. Forty-two types in all have been isolated and a paper on this subject has been written up for publication in the *Indian Journal of Agricultural Science*. The climatic conditions in these parts, unlike those in Bengal and Bihar, do not favour the cultivation of late maturing paddy varieties. The onset of cold in the month of November has an adverse effect on grain-setting and grain-filling. The early rices, therefore, predominate.

The classification of the types has been based on the morphological characters of grain, glumes, etc. The main divisions are based on the chemical constitution of the rice kernal, presence and absence of clustering in spikelets and length of the outer glume. After this the colour of the inner glume has been taken as the most suitable criterion. The inner glume exhibits a wide range of easily distinguishable colours and affords a ready and convenient means of discrimination. Next to the colour of the inner glume, the colour of the apiculus is the most important criterion. This colour is either restricted to the extreme tip or is spreading. After the apiculus the colour of the outer glumes is used, then the colour of the kernal and internodes and finally the grain size and shape which are the most constant among the quantitative characters, have been used in separating the ultimate classes.

Since this work is in continuation of the classification carried out at Pusa where 123 types have been isolated, the 42 types isolated at Karnal have been numbered from 124 to 165.

Types 125 and 130 are very promising. These types were tested last year against Pusa Type 97 and Pusa Type 60 paddies in a randomized block lay-out. It is evident from the results given below in Table III that these types have out-yielded the rest, the difference being statistically significant. Both these types possess somewhat long and slender grains, and stand out well in the field. The yield trial is being repeated again in the next season.

TABLE III
Paddy yield trial (Varietal)
Comparison of Paddy types K. 50, K. 102, K. 137, K. 151, P. 60 and P. 97
Plan and yield in lbs. per plot

K. 50 49.00	K. 151 41.75	K. 102 27.75	P. 60 21.00	K. 137 45.75	P. 97 48.38	K. 137 47.25	K. 151 44.25	P. 60 22.25	P. 97 44.25	K. 102 37.25	K. 50 47.75
K. 151 41.75	K. 102 25.63	K. 137 47.25	K. 50 42.75	P. 97 48.38	P. 60 18.13	P. 60 22.00	K. 50 42.75	K. 151 44.38	K. 102 33.25	P. 97 37.75	K. 137 48.25
P. 60 22.50	K. 137 50.00	K. 151 39.00	P. 97 44.50	K. 102 25.63	K. 50 48.50	K. 102 28.50	K. 137 48.80	P. 97 45.63	P. 60 18.25	K. 50 44.50	K. 151 41.00

System of replication—Randomized blocks (6 varieties and 6 replications).

Area of each working plot—40' × 14'—(1/77.78 acre).

Transplantation date—20th July 1934.

Harvesting date—25th October 1934.

Previous crop—Paddy.

Summary of Results (Grain)

	Mean yield in lbs.					General mean	Standard error of difference	Significance of "Z" test	Critical difference for significance in lbs. per acre
	K. 50	K. 102	K. 137	K. 151	P. 97	P. 60			
(1) Per acre	3568.15	2307.73	3724.88	3238.31	3425.32	1692.60	139.08	Significant	38.763 at 1 per cent level
(2) Percentage on general mean.	119.18	77.09	124.49	103.17	116.42	54.53	..	..	..

(1) K. 137 = K. 50 = P. 97 but superior to K. 151, K. 102 and P. 60.

(2) K. 50 = P. 97 = K. 151 but superior to K. 102 and P. 60.

(3) P. 97 = K. 151 but superior to K. 102 and P. 60.

(4) K. 151 superior to K. 102 and P. 60.

(5) K. 102 superior to P. 60.

The differences are significant at 1 per cent level

GRAM (*Cicer arietinum* L.)

All the 24 Pusa types of gram as well as the following crosses were grown :—

- | | | | | | | | |
|------------------------|---|---|---|---|---|---|---------------------------|
| (1) Cross T. 35 × T. 2 | . | . | . | . | . | . | F ₂ generation |
| T. 2 × T. 35 | . | . | . | . | . | . | Do. |
| (2) Cross T. 39 × T. 2 | . | . | . | . | . | . | Do. |
| T. 2 × T. 39 | . | . | . | . | . | . | Do. |

Unfortunately all these were severely attacked by *Rhizoctonia*. The damage done in certain types was more than in others but the crosses in particular suffered heavily, with the result that very few plants survived. An attempt will be made to repeat the crosses next year.

Last year a stray plant with simple leaves but similar to T. 17 in flower colour and character was detected in gram type 17. The seeds of this plant were sown during this year. Out of thirteen plants produced, ten were like the stray plant possessing simple leaves while the remaining three were like T. 17, having compound leaves. The character of simple leaves, therefore, appears to be dominant over that of compound leaves.

Grams T. 17, T. 25, T. 48, T. 58, T. 67 and the local variety were tested for yield in randomized blocks. The results are given below in Table IV.

TABLE IV

Gram yield trials (varietal)

Comparison of Gram Pusa types 17, 25, 46, 58, 67 and Karnal local gram

Plan and yield in lbs. per plot

T. 25 32.87	T. 58 50.81	T. 46 44.19	Local 64.87	T. 17 50.56	T. 67 45.69	T. 17 52.12	T. 58 57.50	T. 25 65.94	Local 58.81	T. 67 26.69	T. 46 68.00
T. 46 52.25	T. 26 53.81	Local 56.81	T. 67 45.81	T. 17 57.69	T. 58 61.87	T. 46 61.19	Local 58.47	T. 17 53.94	T. 67 54.31	T. 58 63.75	T. 25 70.37
T. 58 39.82	T. 67 54.81	T. 46 53.94	T. 25 66.31	Local 61.37	T. 17 62.56	T. 58 58.81	T. 67 39.00	Local 65.75	T. 25 71.50	T. 17 65.69	T. 46 67.19
T. 17 52.81	T. 25 57.81	T. 67 58.62	T. 58 64.87	T. 46 70.94	Local 73.31	Local 69.31	T. 58 73.56	T. 46 77.50	T. 67 63.69	T. 25 76.81	T. 17 67.25

System of replication—Randomized blocks (6 varieties and 8 replications).*Area of each working plot*—84' x 16'—(1/32.41 acres).*Sown on*—6th October 1934.*Harvested on*—10th April 1935.*Previous crop*—Wheat.

Summary of results (grain)

	Mean yield in lbs.					General mean	Standard error of treatment mean	Whether general effect of treatment is significant by "Z" test	Critical difference for significance in lbs. per acre
	T. 25	T. 58	T. 46	Local	T. 17	T. 67			
Per acre . .	2015.25	1988.35	2006.18	2060.30	1874.27	1574.48	1919.805	87.52644	318.27 at 1 per cent
Percentage on general mean.	104.98	103.57	104.50	107.32	97.63	82.002	100	..	..

(1) Local Type 25, Type 46, Type 58, Type 17.

(2) Local Type 25, Type 46, Type 58 > Type 67 at 1 and 5 per cent levels.

(3) Type 17 < Type 67 at 5 per cent level.

PEAS (*Pisum sativum* L. and *P. arvense* L.)

The variety 14-1 (T. 29) selected at Pusa was grown on a field scale, without supports this year. The yield of grain obtained was 2,355 lbs. per acre. Thus this type which is a dwarf garden variety possessing large wrinkled seeds, does well at Karnal also.

Seed multiplication of improved Pusa types of crops

A large portion of the area of the Sub-station was under the following improved varieties of crops which are in constant demand.

Crop	Variety	Area sown in acres	Crop	Variety	Area sown in acres
Wheat . .	P. 4 . .	9.69	Paddy . .	Type 125	0.63
	P. 12 . .	4.63		" 129	0.65
	P. 12-2 . .	1.14		" 130	0.64
	P. 80-5 . .	14.58		Pusa 97	0.65
	P. 111 . .	10.38		" 60	0.75
	P. 114 . .	6.78		" 52	0.40
	P. 120 . .	2.55		" 24	0.75
Gram . .	P. 165 . .	6.43	Linseed . .	Type 12	3.18
	Type 17	3.36		" 121	
	" 25	5.01		" 124	
Oats . .	" 58	5.29		Hybrids	
	Hybrids	1.74		10, 21, 55,	
Peas . .	C. G. J. & B. S. 2.			68 and flax	
	14-1 . .	1.17			

III. SEED DEMAND AND DISTRIBUTION.

The demand for improved seed is increasing year by year and in many cases the seed indents had to be refused or could only be partially fulfilled. During the current year there was a big demand for wheat types, P. 4, P. 12, P. 80-5 and P. 114, and all the available seed has been booked up for supply. Similarly there was a large demand for seeds of gram types 17 and 25 but this could not be met as the quantity available for distribution was far too short of the demand. The seed distribution during the year is shown in the following statement :—

Statement of seed distributed during the year 1934-35

Variety	Quantity in lbs.
<i>Wheat—</i>	
P. 4	4237.7
P. 12	3569.2
P. 80-5	11059.2
P. 111	4241.9
P. 112	57.6

	Variety	Quantity in lbs.
P. 114		4640.9
P. 120		3474.5
P. 165		3071.3
<i>Gram—</i>		
T. 58		15634.3
T. 17		1974.9
<i>Oats—</i>		
Hybrid G		82.3
„ J		4032.2

IV. STATEMENT SHOWING THE CROP RETURNS OF THE
BOTANICAL SUB-STATION, KARNAL FOR 1934-35

Area	Plot No	Crop	Area in acres	Actual yield in lbs.	Calculated outturn per acre in lbs.
General	6 to 8 . .	Gram T. 17 . .	3.36	3949.7	1175.50
	13 to 16 . .	„ T. 25 . .	5.29	11190.9	2115.48
	9 to 12 . .	„ T. 58 . .	5.01	7868.5	1570.55
	20 to 23 . .	Wheat P. 4 . .	9.69	10306.3	1063.60
	1 to 5 . .	„ P. 12 . .	4.63	5348.6	1155.20
	43 to 51 . .	„ P. 80.5 . .	14.58	23081.2	1583.07
	24 to 28 . .	„ P. 111 . .	10.38	19789.8	1039.48
	17 to 19 . .	„ P. 114 . .	6.78	7843.8	1156.90
	30 to 34 . .	„ P. 165 . .	6.27	6829.7	1089.26
	29 . .	Oats B. S. 2 . .	0.35	676.8	1933.71
	„	„ C . .	0.35	808.5	2310.00
	„	„ G . .	0.35	880.5	2515.71
	„	„ J . .	0.69	1750.6	2537.10
	42 . .	Linseed T. 12 . .	0.75	824.9	1099.87
	„	„ T. 121 . .	0.50	580.1	1160.20
	„	„ T. 124 . .	0.75	660.4	880.53
	„	„ H. 10 . .	0.25	201.6	806.40
	„	„ H. 21 . .	0.25	228.3	913.20
	„	„ H. 55 . .	0.25	207.8	831.20
	„	„ H. 68 . .	0.25	265.4	1061.60
	„	Flax . .	0.18	82.3	457.22
Experi- mental	10 . .	Wheat P. 12.2 . .	1.14	1919.3	1683.59
	15 & 16 . .	„ P. 120 . .	2.55	4696.5	1841.76
	2 . .	Peas 14-1 . .	1.17	2748.3	2348.97
	1 . .	Sann-hemp . .	1.09	1472.9	1351.30
Paddy	1 . .	Paddy T. 125 . .	0.63	1351.5	2145.24
	„	„ T. 127 . .	0.65	1127.3	1734.31
	„	„ T. 130 . .	0.64	1814.4	2835.00
	„	„ T. 164 . .	0.92	1431.8	1556.30
	„	„ P. 97 . .	0.65	1872.0	2880.00
	„	„ P. 60 . .	0.75	946.3	1261.73
Building area.	1 . .	Wheat P. 165 . .	0.41	1149.9	2304.65

(3) SCHEME FOR BREEDING RUST-RESISTANT WHEATS

[B. P. Pal, M.Sc., Ph.D. (Cantab.), F.L.S.]

The scheme which is financed by the Imperial Council of Agricultural Research provides for the breeding of rust-resistant wheat at the Botanical Section, Pusa, and at a Sub-station at Simla. The work is being carried out in collaboration with Dr. K. C. Mehta the results of whose investigations on wheat rusts in India are being utilised in drawing up the breeding programme.

The scheme officially commenced on the 7th April 1935 when Mr. M. A. Aziz, B.Sc. (Agri.), was appointed Wheat Breeding Assistant with headquarters at Simla, but actually work was started last October when wheats to be used as parents for making crosses were sown both at Pusa and at Simla. The series of crosses mentioned in the original scheme has been successfully made as well as a large number of other crosses which it was thought might prove of value for breeding purposes. The full list is given below :

List of wheat crosses made at Simla during 1934-35.

Serial No.	Cross	Number of grains obtained	
		(Direct)	(Reciprocal)
1	Vernal × Khapli	8	17
2	Khapli × Kota	11	2
3	" × Reliance	8	15
4	" × Chinese White	8	12
5	" × T. sphærococcum	3	..
6	" × P. 4	5	3
7	" × P. 12	9	..
8	" × P. 114	2	..
9	" × P. 165	7	2
10	" × C. 518	21	2
11	Kota × Reliance	3	..
12	" × April Bearded	17	7
13	" × Chinese White	4	..
14	" × P. 114	10	..
15	" × C. 518	7	1
16	Reliance × Chinese White	14	14
17	" × April Bearded	5	10
18	" × P. 114	32	12
19	" × C. 518	9	11
20	T. sphærococcum × Chinese White	1	19
21	" × P. 52	1	4
22	" × P. 4	2	5
23	" × P. 12	1	2

Serial No.	Cross	Number of grains obtained	
		(Direct)	(Reciprocal)
24	Chinese White × P. 4	10	13
25	„ × P. 12	9	19
26	„ × P. 80-5	7	10
27	April Bearded × Red Marvel	19	14
28	„ × Square Head's Master	32	4
29	„ × Chinese White	9	..
30	Red Marvel × Square Head's Master	17	21
31	Square Head's Master × P. 52	10	22
32	Mediterranean × Karsten's V	5	14
33	„ × Spalding's Prolific	15	12
34	„ × April Bearded	3	..
35	„ × P. 4	13	..
36	„ × P. 12	48	7
37	„ × P. 52	8	..
38	„ × P. 80 5	17	..
39	„ × P. 114	12	1
40	„ × P. 165	20	26
41	„ × C. 518	8	18
42	Karsten's V × Democrat	17	20
43	„ × Pusa 4	16	3
44	„ × Pusa 80-5	15	7
45	„ × Pusa 101	25	3
46	„ × Pusa 111	25	..
47	„ × Pusa 114	21	2
48	„ × Pusa 165	42	10
49	„ × C. 518	31	..
50	Spalding's Prolific × Democrat	24	13
51	„ × Pusa 4	23	1
52	„ × Pusa 52	10	13
53	„ × Pusa 80-5	14	14
54	„ × Pusa 114	15	13
55	„ × Pusa 165	45	9
56	Democrat × Pusa 4	4	..
57	„ × Pusa 80-5	28	..
58	„ × Pusa 52	13	..
59	„ × Pusa 165	10	..
60	„ × C. 518	14	..
61	Pusa 4 × April Bearded	1	..
62	„ × Yeoman II	9	..
63	„ × Iron	4	..
64	Pusa 12 × April Bearded	1	..
65	„ × Karsten's V	3	..
66	„ × Spalding's Prolific	4	..
67	Pusa 52 × Khapli	9	..
68	„ × Chinese White	4	..
69	„ × Karsten's V	15	..

Serial No.	Cross	Number of grains obtained	
		(Direct)	(Reciprocal)
70	Pusa 80-5 × T. spheerococcum	3	..
71	" × Khapli	1	..
72	" × Red Marvel	11	..
73	" × April Bearded	8	..
74	" × Pusa 114	10	..
75	Pusa 114 × Karsten's V	3	..
76	" × Square Head's Master	6	..
77	" × Chinese White	4	..
78	" × April Bearded	5	..
79	" × Pusa 80-5	8	..
80	" × Pusa 111	10	..
81	" × Pusa 165	13	..
82	" × Yeoman II	4	..
83	" × T. spheerococcum	5	..
84	Pusa 101 × T. spheerococcum	9	..
85	" × Chinese White	3	..
86	" × Spalding's Prolific	4	..
87	" × Little Joss	12	..
88	" × Iron	6	..
89	" × Khapli	4	..
90	" × Rivet (Cambridge)	5	19
91	Pusa 111 × April Bearded	4	..
92	" × Chinese White	10	..
93	" × Khapli	1	..
94	" × Pusa 114	10	..
95	" × Spalding's Prolific	8	..
96	" × Iron	3	..
97	Pusa 165 × T. spheerococcum	2	..
98	" × Rivet	15	4
99	" × Chinese White	16	..
100	" × April Bearded	3	..
101	" × Square Head's Master	7	..
102	" × Red Marvel	1	..
103	" × Iron	2	16
104	" × Yeoman II	11	8
105	" × Pusa 114	13	..
106	" × C. 518	7	..
107	C. 518 × T. spheerococcum	13	..
108	" × Chinese White	15	..
109	" × Pusa 111	6	..
110	" × Pusa 114	6	..
111	Pusa 101 × Yeoman II	16	..
112	Little Joss × Pusa 165	6	..

The F_1 generations of all these crosses will be grown and studied at Simla this winter.

{4 SCHEME FOR POTATO BREEDING IN NORTHERN INDIA

[B. P. Pal, M.Sc., Ph.D. (Cantab.), F.L.S.]

This scheme whereby the breeding of improved varieties of potatoes is to be undertaken at Pusa (and subsequently Delhi) and at a substation in the hills, the latter financed by the Imperial Council of Agricultural Research, came into operation on the 1st April 1935.

Mr. Pushkar Nath, M.Sc. (Hons.), was appointed Assistant-in-charge of the substation, with temporary headquarters at Simla, and K. Pathak, a First Grade Mali from the Botanical Section, Pusa, was temporarily transferred to Simla to officiate as Fieldman. Pending the final selection of a site for the substation, accommodation at the Rust Research Laboratory, "Flowerdale", Simla E., was kindly provided by Dr. K. C. Mehta, and a small temporary staff was recruited to assist the Assistant-in-charge.

To determine the most suitable site for potato breeding work, a standard set of potato varieties has been grown at six hill-stations, namely, Simla, Murree, Kulu, Chaulhatta, Ramgarh and Shillong by arrangement with the Directors of Agriculture of the Provinces concerned. Detailed notes on flowering and berry formation are being taken and the selection of the site for the substation will be based on the information collected.

Attention is being concentrated at present on the collection and study of potato material from different parts of India and from abroad. This work was commenced at Pusa last year and already a fair amount of material has been collected and is now growing at Simla.

REPORT OF THE SUGARCANE EXPERT

(Rao Bahadur T. S. Venkatraman, B.A., I.A.S.)

I. CHARGE AND STAFF

I held charge of the Office of the Government Sugarcane Expert throughout the year except for 14 days leave on average pay during July 1934 when the Second Cane Breeding Officer, Mr. N. L. Dutt, M.Sc., held charge. The Second Cane Breeding Officer was on leave for 28 days in May 1935 when his Senior Botany Assistant—Mr. M. K. Krishnaswami, M.A.—held charge of the post in addition to his own duties.

II. SUGARCANE BREEDING.* (MAINLY SUB-TROPICAL TYPES)

(a) BREEDING TECHNIQUE

The breeding technique during the year was more or less the same as in previous years. The raising of seedlings and hardening them for long journeys by rail to Experimental Stations in North India are tending to become annual routine. Certain of the selections made in North Indian Stations from such material have shown promise of usefulness. The modified method of topping canes with the object of influencing their time of flowering, mentioned in the previous report, gave disappointing result.

The quality of water used in irrigating seedlings during the early nursery stages appears to be an important factor for proper stand and growth. Certain of the crosses, particularly the intergeneric ones, are intolerant to water containing salts; and the presence of organic matter in irrigation water appears to conduce to vigorous growth. The importance that has been attached to vigour of growth in recent years has appreciably raised the standard of selections made.

(b) THE BREEDING PROGRAMME

(i) *Parents*.—The search for useful parents was continued and resulted in two additions, viz., Co. 331 and Co. 508. Co. 331 is useful for introducing both vigour and good habit and Co. 508 for introducing early high sucrose.

* The breeding of tropical types is detailed in the report of the Second Cane Breeding Officer. (Section IX).

(ii) *Inbreeding*.—The programme of inbreeding carried on with Co. 214 has proved useful in yielding seedlings as immune to mosaic as Co. 214 itself and others giving high early sucrose in juice, another prominent character of Co. 214.

(iii) *Cross pollinations made*.—The preceding drought shifted somewhat the relative times of flowering of the parents, with the result that cross pollinations, difficult or not possible in previous years, were done with considerable ease during the year. One such was Co. 349 × Co. 313, a combination intended mainly for Shahjahanpur in the United Provinces.

During the year thirty experimental crosses were made, to get ideas about the type of seedlings produced. Five crosses—which as experimental crosses had shown promise of usefulness in previous years—were made on a mass scale, the mother parents employed being Co. 213 and Co. 349 and the pollen parents Co. 244, Co. 285, Co. 312 and Co. 313.

(c) DESCRIPTIONS OF NEW SEEDLINGS

It has been the practice to describe from time to time, and in some detail, new Coimbatore canes as they prove useful in cultivation. Description of seven such canes have already been published; a second batch of seven was thus described during the year by Mr. S. A. Hussainy. These were studied in all the important Sugarcane Testing Stations in India.

III. CYTO-GENETICAL STUDIES

Cyto-genetical studies in sugarcane are a recent development, perhaps the most notable contribution so far being from Java. While some cytological work has been in progress at the station from about 1932, it was thought desirable to extend the same by employing a whole time Geneticist and this was rendered possible through funds kindly sanctioned by the Imperial Council of Agricultural Research. Dr. Miss E. K. Janaki Ammal, M.A., M.Sc., D.Sc., F.L.S., worked as Geneticist throughout the year.

The cytology of the different types of *Saccharum spontaneum*—of which a fair collection is available at the station—was one of the first subjects to receive attention. It would appear probable that the primitive forms of *S. spontaneum* are those with a relatively low number of chromosomes and certain of these forms occur in India. The Dacca form—which is the nearest to *Saccharum officinarum* in morphological characters—possesses the same number of chromosomes as both *S. officinarum* and *S. robustum* Jeswiet (the vigorous wild form collected from New Guinea). Evidence from chromosome numbers and behaviour indicate hybridity within the species. The results are being written up for publication.

The inter-specific crosses studied during the year included Vellai × *S. Narenga*, Vellai × *S. spontaneum* and P. O. J 2725 ×

various types of *S. spontaneum*. A careful examination was made of the intergeneric hybrids with *Sorghum*. A search for definite characteristics in the morphology of *Sorghum* chromosomes revealed two chromosomes with trabants in *Sorghum Durra* Stapf, *Sorghum Versicolor* and *Sorghum halepense* showed 10 and 40 chromosomes respectively and *Saccharum arundinaceum* 40 chromosomes.

Many controlled crosses were made for obtaining reliable material for cytogenetical work in the genus *Saccharum*. The necessary artificial emasculation presented considerable difficulties on account of the smallness of the flowers, but the work has yielded a certain amount of material. Controlled crosses were made using Vellai, *Gigas* and Kassoer as the female parent and *Sorghum Durra* Stapf as pollen parent. The reciprocal crosses with *Sorghum* as female parent proved unsuccessful. A certain number of interesting back crosses were effected between *Sorghum* hybrids and *Sorghum*, Co. 205 and *Saccharum spontaneum*, and Kassoer \times Glagah.

Various improvements in technique were effected both in field cross pollination and in the laboratory. An attempt to induce somatic mutations in cane by various forms of bud mutilations and topping the plants yielded certain abnormal buds, but callus formation—as was to be expected—was rare. This work will be continued in subsequent years.

IV. RESEARCH

(a) TYPES OF *SACCHARUM SPONTANEUM*

The collection of *Saccharum spontaneum* from Bihar by Mr. R. Thomas in 1933 is proving of rather unusual interest. Besides wide differences in morphological characters, the types collected show interesting variations both in depth and method of branching of roots. One of the types analysed gave as high as 13 per cent sucrose in juice and yet another would appear to represent a form intermediate between *Saccharum spontaneum* and *S. arundinaceum*. This incidental exploration of just a portion of Bihar is indicative of possibilities if and when other portions of the country are systematically explored for wild forms of *Saccharum*.

Seed viability tests showed that certain of the Indian forms retained viability longer than those from Burma or the Eastern Archipelago.

(b) MOSAIC INCIDENCE

Aphis maidis rarely colonises freely on sugarcane at the station not even on the susceptible kinds. Preliminary experiments by Mr. R. Thomas showed, however, that they do colonise more freely when the plants are grown in an etiolated condition by cutting off light. A rough inverse correlation was noticed between

the degree of resistance and the ease with which the insects colonise on the different canes under study. The colonies soon died on shoots of Co. 214 and Co. 335—two seedlings known to be immune—but lived for sometime on the susceptible canes. The work will be continued as it might ultimately lead to the development of a technique for picking out canes resistant or immune to mosaic.

Help was given to the Government Mycologist at Coimbatore for germinating sugarcane seeds and tending them during their early stages to ascertain if mosaic is transmitted through seed. The results are reported to have negatived such transmission.

(c) SUGARCANE \times SORGHUM HYBRIDS

Certain of these hybrids which were continuously back-crossed with *Sorghum* yielded seedlings which, in their floral structures, approach closer to *Sorghum Durra* Stapf. This was particularly noticeable in the size of fruit and callus hairs and the awn in the fourth glume. The cane Vellai was successfully crossed with various types of *Sorghum* and *Erianthus* for cytological studies.

(d) CANE GERMINATION

Studies on cane germination indicated that material from arrowed canes was inferior to that from non-arrowed ones in that they took longer to germinate. Standing canes, topped in the field sometimes before use as planting material, showed quicker and better germination. This method might be of some use in experimental stations, at least, for maintaining a satisfactory stand in the plots. Attempts to correlate ash content with germination did not give any definite indications.

(e) ARROWING IN SUGARCANES

Arrowing—at any rate under Coimbatore conditions—was again found to be not an indication of ripeness. The arrowed canes of the same variety were found to be distinctly superior to the non-arrowed canes for about two months after arrowing and in all respects, including weight and juice quality. The arrowing of sugarcanes at the station is mainly during October–November. After that period, while a steady improvement is noticed in the non-arrowed canes till April, the arrowed ones show but little improvement. The results are being written up for publication.

V. DISTRIBUTIONS FROM THE STATION

(a) AS TRUE SEED

Seeds of Co. 349 \times Co. 212 ♂ and Co. 349 \times Co. 313 ♂ were preserved and sent to the Economic Botanist at Shahjahanpur and of *Saccharum robustum* to Mauritius for germinating at the two places.

(b) AS SEEDLINGS

Five thousand seedlings of Co. 213 crossed with Co. 285 and Co. 244 were sent to the Sub-station, Karnal and about an equal number of Co. 349 crossed with Co. 312 and Co. 313 to the Sugarcane Research Station at Shahjahanpur, by railway in through wagons after hardening them for the journey. Work at both the above stations is financed by the Imperial Council of Agricultural Research.

(c) AS CANES

About 200 packets containing over sixty varieties, mostly Co.'s, were distributed to 90 places within the limits of India. Twenty-seven packets were sent to Natal, Durban, Gold Coast, Kumasi, Formosa, United States of America and Iran.

VI. PERFORMANCE OF COIMBATORE CANES**(a) COIMBATORE CANES IN INDIA**

The marked feature during the year has been the good opinion earned by the thick type of Co. canes bred by the Second Cane Breeding Officer, Mr. N. L. Dutt, M.Sc. Of the many thick types under test in various experiment stations, Co. 419 is easily the most outstanding for tropical conditions. It has shown better growth than the "wonder cane" of Java—P. O. J. 2878—in certain parts of tropical India. Very good preliminary reports have also been received about the performance of Co. 421 from more than one station in Northern India. It is likely to take a definite place in the future as a semi-irrigated cane.

The more recent Coimbatore seedlings are steadily finding a place in subtropical India as further improvements over the Coimbatore types already popular there. One such is Co. 331 which combines both vigour and good habit and promises to be useful as a late season cane. Another such is Co. 312 which, though not satisfactory in habit, gives high yields and resists summer conditions.

Quite recently there has been a big expansion of sugarcane area in the tract commanded by the Nizamsagar canal in Hyderabad. Co. 213 is reported to have been largely responsible for this expansion. Owing to the light nature of the soil, cane growing used to be costly because of wooden props which had to be used to prevent lodging; Co. 213 through its excellent habit does not require such supports and besides requires less water.

(b) COIMBATORE CANES IN FOREIGN COUNTRIES

The canes produced at Coimbatore are receiving increased recognition in many foreign countries particularly because of their greater resistance to diseases and pests and the comparatively less favourable conditions under which they are able to thrive.

Co. 281 has proved resistant to "Streak" in South Africa and to "pine apple" disease in Porto Rico. Co. 290 has proved resistant to many diseases including the "gumming" disease in Australia. Co. 213 has shown utility on low lands in Cuba overrun with grass and is a favourite in Brazil.

VII. PARENTAGE OF COIMBATORE SEEDLINGS

Co. 432 . . .	P. O. J. 2727 × Co. 285.
Co. 433 . . .	} P. O. J. 2878 General collection.
Co. 434 . . .	
Co. 435 . . .	(Likely father E. K. 28).
Co. 436 . . .	Co. 363 × P. O. J. 2727.
Co. 437 . . .	Co. 364 × [Kassoer × B. H. 10 (12)].
Co. 438 . . .	} Co. 408 × Co. 415.
Co. 517 . . .	
Co. 518 . . .	Co. 290 × Co. 335 (Co. 214 self).
Co. 519 . . .	Co. 214 self.
	Co. 290 × Co. 313.

VIII. THE KARNAL SUBSTATION

(a) GROWTH CONDITIONS DURING THE YEAR

The summer during the crop season was of the usual severity in the tract though severer than in the previous season. The rainfall (33·09") was a trifle more than the average of 29" to 30" but the distribution was agriculturally less useful. The frost was severer than usual and continuous. The crop under study experienced four continuous frosty nights against the fewer and more disconnected frosty nights recorded for the three previous crops. This killed a considerable portion of the crop in South East Punjab and West United Provinces and led to a great demand for seed from the cane growers. Of the four crops raised at the Substation so far, the last suffered the most from two serious pests of the tract—*viz.*, *Pyrilla* and *Top Borer*. This afforded a good opportunity to study their relative incidence on the different canes under test.

(b) SEEDLINGS UNDER TEST FROM THEIR EARLY NURSERY STAGE

Five thousand and eight hundred such seedlings, composed of equal numbers of Co. 213 × Co. 285 and Co. 213 × Co. 244, were grown during the year. These ultimately yielded fifty-five preliminary selections, five of which were superior in juice quality to Co. 285—the now popular cane in the Punjab and promising to be so in West United Provinces. One hundred and twenty-six seedlings selected as above from the previous-year-lot and grown during the year in rows for further selection gave twenty-two types.

Besides the above, 6,500 seedlings in the nursery stage were imported from Coimbatore during the year. The crop of seedling

canes at the Sub-station thus represented over 17,000 new seedlings grown at Karnal from the nursery stage and now in different stages of trial.

(c) STUDIES OF SEEDLING CANES IN REGULAR TEST PLOTS

The number of seedlings which were selected for detailed study during the year was forty two. It is found it takes generally three years for a new seedling, grown at Karnal from the nursery stage, to reach this status. The studies were on the same lines as in previous years with slight improvements in technique.

(1) *Resistance to adverse conditions*

(i) *Summer drought*.—The summer during the year which was fairly severe showed the undermentioned canes to be resistant to summer conditions in descending order. This conclusion was arrived at by the methods described in previous reports.

Co. 312, Co. 290, Co. 285, Co. 356, Co. 313 and Co. 331. Co. 244 and Co. 213 were found to be distinctly inferior to the above in this respect.

(ii) *Frost*.—Frost during the year was comparatively severe and continued for a fairly long period. Root systems of sugar-canes vary in their depth at different periods of their life cycle. A correlation was indicated between the depth of roots at time of frost incidence and frost resistance. Of the eleven varieties, whose roots were six feet deep a little before frost, 82 per cent escaped with slight injury and 18 per cent were moderately affected. On the other hand, of the thirteen varieties whose roots were only three feet deep at the time, 61·6 per cent escaped injury and 15·3 per cent were moderately and 23·1 per cent seriously affected.

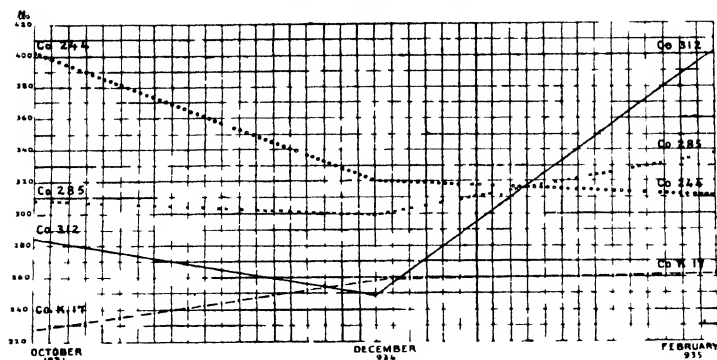
It was also noticed that lodged canes were more affected than unlodged canes of the same variety thus emphasizing the value of good habit for sub-tropical conditions.

(iii) *Insect pests*.—All the forty two varieties in the test plots were periodically examined for degree of attack from *Pyrilla* and *Top Borer*, the two dominant pests during the year. The Government Entomologist, Punjab, to whom my grateful thanks are due, gave all possible advice and help in studying relative incidence. Recently, he has kindly transferred the Headquarters of his Assistant from Sonpet to Karnal and I have promised him facilities at the Sub-station.

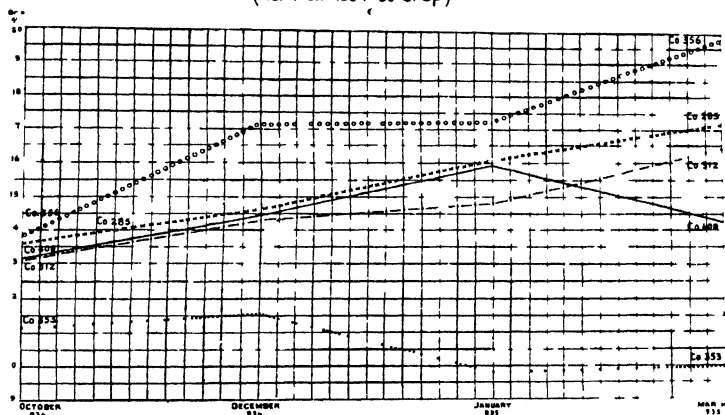
Pyrilla.—This was found on all the canes, none being altogether immune. Co. 285 and Co. 408 were least affected and Co. 312 and Co. 356 among those moderately affected.

Top Borer.—The Assistant to the Government Entomologist, Punjab, kindly examined the crop and favoured me with figures indicating the degree of incidence. It is satisfactory that Co. 331—a promising cane of the future—is relatively resistant.

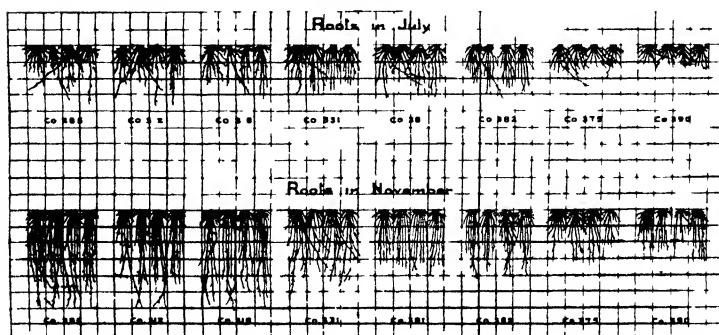
Periodic weights of millable canes (Karnal 1934-35 crop)



Brix Readings (Karnal 1934-35 crop)



Root Dissections Karnal 1935



(iv) *Lodging from high winds and cyclones.*—The monsoon period at Karnal is often followed by high winds which not infrequently develop into cyclones. The nature of soil is such that it gets sodden after rains or heavy irrigation, and gives little hold for the cane roots and facilitates lodging. Even under such conditions Co. 331, Co. 205, Co. 213, Co. 313, Co. 318 and Co. 341 showed practically no lodging; canes like Co. 244, Co. 312 and Co. 290, on the other hand, lodged badly, the first being the worst in this respect. As lodging, besides rendering the canes more liable to frost, injuriously affects juice quality on account of the shooting of buds; this is a major draw-back in canes intended for this tract.

(2) *Life cycle of the canes under test*

(i) *Cane yields.*—The quantity of millable canes obtained per acre is an important factor in determining harvest yields be it gur or white sugar. Periodic weighments of millable canes of ten rows each 20 feet long at each observation yielded some useful data. The manner in which each variety builds up its cane tonnage is important as this, combined with the periodical juice analyses, is useful in determining the most profitable time for harvesting the different varieties. Periodic weights of four such canes are graphed in Plate III, Fig. 1. It will be noticed that, whereas both Co. K. 17 and Co. 285 show a steady increase in weight of canes, Co. 244 shows an appreciable drop from October, apparently resulting from certain of its canes getting spoiled or killed by lodging and frost. Co. 312 is obviously best harvested late in the season as it builds up considerably in cane weight after December. These results confirm the finding in the previous year's report that in certain varieties canes die during the crushing season and are thus lost for harvest.

(ii) *Juice quality.*—An ideal cane, particularly for the small scale Indian grower, would be one which, after reaching satisfactory juice quality early in the season, either maintains it or improves as the season advances. Other canes, whose period of optimum juice quality is comparatively short, necessitate their crushing during a shorter period for securing the best results. This is a disadvantage where for a variety of reasons—including rains at the time—the harvest operations of the small grower are dependent on outside environmental factors. Plate III, Figure 2 gives the periodic Brix readings of three popular canes—Co. 312, Co. 285 and Co. 213—in contrast with two others which have been rejected for this and other reasons. To obtain samples for the above analyses a whole row (20 feet long) was cut and milled, rejecting such shoots as showed no cane formation.

(iii) *Root dissections.*—A positive correlation has already been indicated between root depth at time of frost incidence and resistance of the variety to frost damage. A deeply developed root

system particularly at the critical periods is a great advantage. Periodic dissections in situ (Plate III, Fig. 3) have shown Co. 312, Co. 285, Co. 318 and Co. 331 to be satisfactory in this respect. They show a deep root system both in July and in December. The other seedlings figures are relatively unsatisfactory.

(3) *Results of studies—Co. 285 a safe cane*

The above studies have indicated Co. 285 as the most useful all-round cane for the tract. Its gur is slightly coloured; but on account of its resistance to adverse conditions like drought, frost and *Pyrilla* attack it is the safest cane to grow. The promising canes include Co. 312, Co. 313, Co. 244, and Co. 331. The last named has excellent agricultural characters and might have a definite use as a late-season cane.

(d) BARANI TRIALS

Water being an important and sometimes a costly factor in cane growing, a plot had been laid from the very commencement of the Sub-station to try and select canes which would grow under Karnal conditions without any artificial irrigation. Periodic weighments, root dissections and juice analyses showed that Co. 205 was the best and next Co. 285. Other canes which showed some use from this view point were Co. 326, Co. 341, Co. 318 and Co. 321 in descending order. More canes from the main plots were taken to this area based on their performance during the year.

IX. REPORT OF THE SECOND CANE BREEDING OFFICER

(N. L. Dutt, M.Sc.)

(a) SUGARCANE BREEDING (MAINLY TROPICAL TYPES)

(1) *Crossing Operations*.—An extensive breeding programme was gone through involving as many as 100 combinations. Experience gained from last year's experimental crosses was utilized in giving definite orientation to crossing in certain directions, particularly with regard to the use of Co. 419 and Co. 421 as parents. These two canes besides yielding seedlings of desirable type give very satisfactory germinations of seeds—an important factor in thick cane breeding. The utility of certain other canes as parents was investigated, but their experimental crosses will need to be repeated for another season or two, before finally deciding about their merits.

(2) *Nursery Seedlings*.—Over 1,50,000 seedlings were germinated in seed pans and about half the number transplanted into beds. Finally about 14,000 seedlings were grown in the field plots for the full year tests. In the field the seedlings from the various combinations were grouped in three separate categories:—
(i) seedlings of the type of Co. 402, i.e., noble canes requiring

liberal treatment regarding irrigation and manuring, (ii) seedlings like Co. 419, i.e., general purpose canes which may profitably be grown either in wet lands or in garden lands, (iii) relatively hardy seedlings like Co. 421 which may be grown as semi-irrigated canes either in tropical or subtropical India.

It was felt desirable to divide the seedlings into the above three classes because of the very good preliminary reports about the performance of Co. 419 from certain experiment stations in the Bombay and Madras Presidencies and of Co. 421 from more than one experiment station in North India.

(3) *Selection of Economic types*.—Sixty seedlings were grown in four-row trials and twenty in eight-row trials along with suitable standards. Seven seedlings were finally raised to the status of Co.'s. These are Cos. 432 to 438, and include 2 seedlings of Co. 402 type, 2 of Co. 419 type and 3 of Co. 421 type. Their parent-ages are given elsewhere in the report.

(4) *Type of seedlings yielded by different crosses*.—Nineteen different crosses were studied for the type of seedlings yielded by each of them. For this purpose a block of one hundred seedlings from each combination was taken, and brix, weight, and number of tillers for each seedling recorded. These data are being analysed with a view to ascertaining the relative merits of the different combinations.

(b) RESEARCH

(1) *Flowering habits of certain forms of Saccharum*.—During the season attention was directed to the study of floral characters of 20 varieties. It was found that *Saccharum spontaneum* was the earliest to flower, followed by (i) Glagah, (ii) the thin and medium varieties and (iii) thick canes. The same sequence was noticed regarding closing of the spikelets also. *S. spontaneum* was the first to close, the last being thick canes like Vellai, etc. As regards duration of blooming the time for *Saccharum spontaneum* was 35 to 45 minutes and for medium and thick canes 3 to 4 hours. P. O. J. 2878 was peculiar in that it was the last to open and closed only about 11 a.m. Dehiscence of anthers took place soon after they became pendulous. The slight morning breeze helped the dehiscence of the anthers. Provided there is no heavy breeze pollen clouds are released half to three quarters of an hour after dehiscence. Sessile spikelets open first in thick canes and the pedicelled spikelets in *S. spontaneum* but the opening of both sessile and pedicelled spikelets together was also quite common. Colour of anther does not appear to be the criterion for availability or abundance of pollen in the species of *Saccharum*; as yellowish white anthers in *Saccharum spontaneum* give abundant pollen while the yellowish anthers of *Saccharum officinarum* are usually infertile.

(2) *Vernalization*.—Single budded setts of half a dozen varieties were kept at a temperature of 13° to 15° C., in darkness. The growth of the treated buds after transferring to the field was defective as compared with the controls. The experiment was repeated with only three varieties treated under :

- (i) continuous darkness, and
- (ii) continuous electric illumination.

The varieties treated were Co. 402, Co. 290 and P. O. J. 2725. The treated buds along with the controls have been transferred to the field and observations are being made. For electrical illumination a 500 c.p. lamp was used.

(3) *Photoperiodism*.—The varieties P. O. J. 2725, Co. 290 and C. A. V. 87 were given a six hour day for 35 days. The arrows of P. O. J. 2725 and C. A. C. 87 emerged 14 and 12 days respectively earlier than the control. The arrows of Co. 290 also emerged 14 days earlier than the control.

(4) *Root studies*.—Observations were made on the development of roots of two outstanding thick Co. canes, viz., Co. 419 and Co. 421 as compared with three standard varieties, viz., Cos. 213 and 290 and P. O. J. 2878. The root systems are being exposed and studied at intervals of four weeks.

(5) *Germination in thick cane seeds*.—Data were collected on the following experiments :—

- (i) Number of germinations from different parts of the arrow.
- (ii) influence of the same male parent on different mothers.
- (iii) influence of artificial rooting in single and double tile pots (during isolation) on germination.
- (iv) average germination per arrow in different crosses.

It is proposed to collect similar data for at least three to four seasons.

(6) *Cytological observations*.—Important slides which had been prepared during 1933 and early part of 1934 but which could not be examined owing to pressure of other work were examined by Botany Assistant Mr. K. S. Subba Rao, with a view to the study of secondary pairing. He was able to examine a large number of sections in about a dozen varieties and camera lucida drawings of the same have been prepared. He found that the number of groups formed by bivalents in the metaphase plates ranged from 8 to 10, the latter being by far the most common. This was true even for such forms as *Saccharum spontaneum* (Coimbatore) the haploid number of which is not a multiple of ten. The above might be some indication that the basic number of chromosomes in *Saccharum* might most probably be 10.

(c) THICK TYPE OF CO. CANES

Data about parentages and performance of thick cane seedlings are given elsewhere. Among the thick Co. canes extensively distributed to various experimental stations in India are Co. 419 and Co. 421. These two canes have also been distributed, on request, to a few foreign countries as well.

X. MISCELLANEOUS

At the desire of the Sugar Committee of the Imperial Council of Agricultural Research a standard form was drawn up for "Reports from Sugarcane Testing Stations".

At the desire of H. E. H. the Nizam's Government the area under the Nizamsagar Canal was visited and a scheme for varietal tests drawn up.

The Coimbatore Rind Hardness Testing Apparatus was sent to Manila (Phillipines) in exchange for a squeezer evolved there for the sampling of standing sugarcanes.

Mr. Imdad Ali Khan completed his post-graduate training at the Station.

The visitors during the year included Dewan Bahadur Sir T. Vijayaragavachariar, K.B.E., Vice Chairman, Mr. B. C. Burt, C.I.E., M.B.E., I.A.S., Agricultural Expert, Mr. A. M. Livingstone, Marketing Officer of the Imperial Council of Agricultural Research, Dr. F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., Director, Imperial Institute of Agricultural Research, Mr. S. V. Ramamurthy, I.C.S., Director of Agriculture, Madras, Dr. O. Posthumus of the Sugarcane Experiment Station, Pasoeroean, Java, and Mr. Nizam-muddin Hyder, Director of Agriculture, Hyderabad (Deccan).

XI. PROGRAMME OF WORK FOR 1935-36

The breeding work will be carried on with the object of securing improvements on existing types or cheapening cost of cultivation.

Attempts will be made to improve the technique both in the field and laboratory, to study factors in cane germination, and to follow up changes in juice quality particularly towards maturity.

Cytogenetic studies on the genus *Saccharum* will be continued and extended.

XII. PUBLICATIONS

- (1) Dutt, N. L. . . . Recent advances in Sugarcane breeding in India. *Proc. Assn. Econ. Biol. Coimbatore*—Vol. II, pp. 60-66—1934.

- (2) Gopala Iyer, K. V., Suggested method of juice analyses
and Venkatraman, T. for sugarcane plantations devoid of
S., Rao Bahadur. Laboratory facilities, Part II.
Accepted for publications in
Agri. and Livestock in India.
- (3) Singh, T. S. N. . . Chromosome numbers in sugarcane
 \times *Sorghum*. *Ind. Jour. Agri. Sci.*,
Vol. IV, Part VI, Decr. 1934,
pp. 1050.
- (4) Venkatraman, T. S., Methods of Selecting Seedlings (as
Rao Bahadur. adopted at Coimbatore) Contribu-
tion to the Fifth Congress of the
International Society of Sugarcane
Technologists (Brisbane, Australia,
August 1935).;

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST

(1934-35)

(B. VISWA NATH, F. I. C.)

I. CHARGE

Mr. B. Viswa Nath, on his appointment as the Imperial Agricultural Chemist, took charge of the Chemical Section from Mr. J. N. Mukerjee on the afternoon of the 22nd August 1934 and of the Bacteriological Section from Mr. N. V. Joshi on the 1st November 1934. From this date the Bacteriological Section ceased to be an independent unit and has become part of the Chemical Section. This report, therefore, includes the work on micro-biology which in previous years used to be described in a separate report of the Imperial Agricultural Bacteriologist.

Mr. J. N. Mukerjee, Assistant Agricultural Chemist, was on long leave from 24th October 1934 till the 13th June 1935. During Mr. Mukerjee's absence, Mr. B. M. Amin was in charge of the analytical work.

Mr. N. V. Joshi was in charge of the work on micro-biology throughout the year.

II. GENERAL

The severe earthquake which rocked Bihar on the 15th of January 1934 caused such damage to the laboratories that they became unsafe and unfit for work. It was necessary to provide laboratory accommodation elsewhere. In spite of the uncertainty of the position and dislocation of the normal activities of the Estate, Messrs. Mukerjee and Joshi fitted up temporary laboratories for the conduct of urgent routine work. The salvaging of materials in the damaged buildings and the fitting up of laboratories in other available buildings necessarily took time and it was not till January 1935 that laboratories were available for properly resuming the interrupted research work.

The stocks of apparatus and materials were checked and a list of damages during and incidental to the earthquake, was prepared. It is distressing to mention that several valuable pieces of apparatus were either broken or so damaged as not to be able to function satisfactorily. It will be necessary to replace them if the equipment and the efficiency of the Section are to be at a high level.

Plans for the construction of the laboratories for the new Institute at Delhi and notes on the construction, internal finishings and fittings, were prepared and submitted.

III. METEOROLOGY, DRAIN-GAUGES AND CONTINUOUS DIFFERENTIAL MANURIAL PLOTS

The equipment for these perennial items of work suffered considerably as the result of the earthquake. In view of the shift of the Institute to Delhi in the near future, it was not considered worthwhile repairing the damage. These have, therefore, been discontinued. The data are being tabulated for scrutiny and interpretation.

IV. POST-GRADUATE TRAINING

Mr. Mohini Nath Phookan, M.Sc., completed his two years' training at the end of October 1934. Messrs. Narendra Kumar Das, M.Sc. and K. Swaminathan, M.Sc. entered into their second year's programme of work.

Mr. M. A. Idnani from Sind,

Mr. Sirajuddin Siddique from Bombay,

Mr. S. C. Roy from Assam,

Mr. K. V. S. Satyanarayana from Andhra, and

Mr. C. Parthasarathi from Madras

were admitted as post-graduate students in November 1934.

A new feature of the post-graduate course is the introduction of regular lessons in technical German translations and occasional lectures and discussions on the research work in progress in the laboratories and on the state of the knowledge in different fields of agricultural science.

Three Dairy Diploma students had a course of lectures and practical training under Mr. N. V. Joshi.

Dr. J. K. Dubey, Assistant Director of Agriculture, Bhopal State, who was under general post-graduate training between November 1934 and April 1935, was given facilities to acquaint himself with the work in progress and methods in use in the Section.

V. RESEARCH AND INVESTIGATION

In view of the decision to shift the Research Institute to Delhi in the near future, the Research and Investigational activities of the Section were confined to the completion of the work already on hand or to bring it to such a stage at which it can be kept in abeyance. A few new items which can be conveniently continued at Delhi were, however, taken up.

1. SOILS

Delhi Soils.—The bulk of the work on soils consisted in the examination of the soils round about Delhi, preliminary to the selection of a site for the location of the new Agricultural Institute. Two sites, (1) the Gheora site, (2) the Industrial Area site were under consideration as possible localities. Elaborate and careful surveys of the sites were made and a large number of samples of soils, subsoils and waters were collected and analysed. The waters from the Gheora area are extremely brackish in quality and the wells are shallow and are probably mostly from the seepage water from canal irrigation. Judging from the water level in the well, the subsoil water in the area is dangerously near the surface. It was noted to be 15 to 20 feet from the surface in the month of March, 8 to 10 feet in July and in September it was only 4 to 5 feet from surface. The dissolved solid content of the well waters in the Gheora area varied from 250 to 2,150 parts per hundred thousand parts, the salts being chiefly sodium salts with a preponderance of chloride. Such waters lead to soil deterioration from a sequence of exchange reactions, which ultimately result in the introduction of sodium into the clay complex. Soil management would then become difficult and with intensive irrigation and cultivation the soil is likely to soon become infertile. On the other hand, the well waters of the Industrial Area site are decidedly superior to those of Gheora. The total solid content of the well waters of the Industrial area varied from 48 to 125 parts per 100,000 parts of water and at the end of the rainy season, unlike at Gheora, the subsoil water was found not to have risen appreciably. Even then, the subsoil water was below 20 to 30 feet from the ground surface, while the water column in the well ranged from 20 to 33 feet.

Several samples of soils in both the areas were collected down to a depth of 6 to 8 feet and analysed chemically and physically. In regard to their contents of nitrogen, phosphoric acid and potash there is no appreciable difference in both the sets of soil. In regard to lime reserves, the soils of the Industrial Area are better placed than those of Gheora. The differences, though apparently small, are important enough to merit consideration. The mechanical composition of the surface soils of both the sites does not differ, but in regard to subsoils those of the Industrial Area contain 30-34 per cent. of finer particles (clay + silt) as against 27 to 31 per cent for those of Gheora site. In the Industrial Area site *Kankar* occurs at depths of 6 and 12 feet, in loose nodules and is principally of calcium carbonate. From these considerations, the Industrial Area site was considered as being more suitable than the Gheora site for the location of the Institute, and a recommendation was made accordingly. The recommendation having been accepted, further intensive and extensive studies of these soils have recently been commenced. From the data available so far, the soil appears to be typical of old Jumna alluvium. The available data on the

other soil characteristics are as yet too meagre to comment on the nature of the alluvial soil, that is, whether a soil is developing on the old deposited alluvium or whether it is the accretion of successive layers of fresh alluvium.

Pretreatment of soils for dispersion for Mechanical Analysis.—At the instance of the Imperial Council of Agricultural Research the potassium permanganate method of dispersion was investigated in regard to its applicability to soils other than laterite. The method with a few modifications in the technique gives, in the hands of experienced workers, results closely agreeing with those obtained by the International method. But the process is tedious and presents considerable difficulty in the removal of manganese dioxide formed in the reaction. Apart from this, the method is likely to develop with the majority of Indian soils sufficient alkalinity as to disrupt partially the clay complex and to dissolve iron, alumina and silica.

In recent years, the dispersion of soils for mechanical analysis has received considerable attention in and outside India. The desire to get at the ultimate particle size and to present the results in the form of a continuous curve has been the chief consideration that has prompted soil workers to give to the subject the too much attention that it has had. Several methods have been proposed from time to time and in India the older and simpler pretreatment by boiling has been given up in favour of the one or the other newer pretreatments which are entirely chemical. Either from theoretical or practical considerations there appears to be no justification for this change over. A critical study of the several methods in regard to their applicability to Indian soils was in progress. All the methods of pretreatment are more or less drastic and any one method fails to give an accurate picture of the soils' field behaviour. Several so modify the soil chemically and physically that it entirely differs from the original soil. A critical experimental review of the position will be prepared for publication.

Dew as a factor in the supply of moisture to the Soil and to the plant.—A study on dew as a factor in the moisture economy of the soil, and the contribution made to the growth of *rabi* (winter) crops was commenced in the middle of November both in the laboratory and in the pot-culture house with tobacco seedlings. Tobacco seedlings were planted in pots filled with Pusa soil and were fully exposed to all kinds of weather except rain. No watering was done, Dew was the only source of moisture or water. Under these conditions the tobacco seedlings lived throughout the season, passed through the usual vegetative and reproductive phases. Determinations of moisture in soil at different parts of the day indicated that besides supplying 3 to 4 per cent of moisture in the surface layers, dew deposition takes place even in the lower layers of the soil down to a depth of one foot. It would appear that evaporation.

and absorption phases operate in the soil to an extent that the balance is enough to sustain the normal functions of the plant. At or about the hygroscopic stage, the soil loses appreciable amounts of water during daytime, but during night more moisture than is lost is gained both by direct absorption and condensation in the interior of the soil. This increased with the depth of tillage.

The investigation of acid soil.—The investigations on acidity and lime requirements of soils of Jorhat in Assam reported in previous years were continued. The response to the degree of liming as determined by the potentiometric titration of the soil, varied with the nature of the crop. The effect of lime applications made in the year 1932 persisted during the year under report. Maximum crop yield in pots was obtained in the pots limed to pH 7 and the yields decreased with increasing applications of lime. On the other hand barley plants grew well and yielded the maximum when liming was done at twice the amount required to bring the soil reaction to pH 7.

Photo-nitrification in soil.—The recent claims by the workers of the Allahabad University that sunlight is largely, if not entirely, responsible for bringing about nitrification in the soil were tested. Messrs. Joshi and Biswas carried out a series of experiments with different soils and different nitrogenous materials. They have not been able to find any evidence of the effect of nitrification either in soil or in Remy's solution. On the other hand, they find that direct exposure of soil to strong sunlight inhibited nitrification. The results of the investigation are written up and will be submitted for publication.

Biological activity of soils with reference to manurial treatment.—The estimation of nitrogen fixing and carbon-dioxide evolution capacities of soils collected in different seasons from plots receiving differential manurial treatments were completed during the year under report. The results obtained with samples collected in the years 1932 and 1933 do not show consistent and marked differences due to treatment or season.

Biological Analysis—Punjab Field Experimental Plot—Nitrogen Fixation—Mgm. N. fixed per gram of mannite

Plot No.	Treat- ment	Month	3 Farmyard Manure	10 N + K + P	12 Green Manure	13 No Manure	16 Green Manure and super
1932		March 32 .	8.47	8.82	6.86	7.77	8.75
		June 32 .	8.89	9.38	8.26	8.82	9.52
		Sept. 32 .	7.84	7.84	9.35	8.68	7.14
		Decr. 32 .	7.63	8.19	7.98	7.49	7.35
1933		March 33 .	6.44	8.12	8.19	7.63	7.63
		June 33 .	8.99	9.56	7.63	9.31	9.10
		Sept. 33 .	8.19	9.31	10.36	8.68	9.85
		Decr. 33 .	10.36	9.24	7.56	10.89	8.10

CO₂ evolution with optimum moisture only (carbon added).Mgm CO₂ per 100 grm. soil.

1932	March 32 .	58.96	62.92	55.66	54.78	68.42
	June 32 .	84.04	72.60	81.62	55.66	69.08
	Sept. 32 .	56.76	58.08	54.56	51.70	59.64
	Decr. 32 .	31.68	62.92	52.36	56.76	80.96
1933	March 33 .	69.52	66.00	73.26	59.40	68.64
	June 33 .	88.66	59.40	51.92	42.02	41.80
	Sept. 33 .	69.08	54.34	55.88	66.00	71.50
	Decr. 33 .	60.06	61.16	66.00	59.40	66.00

2. FERTILISERS AND MANURES

Nitrification of Calcium Cyanamide in Soil.—It was reported in previous years that while Calcium Cyanamide nitrified normally in many soils, there were some soils in which it took very long—even as long as seventy-two weeks—to nitrify, although ammoniacal nitrogen was found to form in about two or three weeks' incubation. This lag period varied with the soil. It was also found that the lag period was not connected with the reaction of the soil and that the refractive soils were not lacking in nitrifying organisms. Water extracts from lag cultures did not inhibit or appreciably retard nitrification when inoculated into Omelianski solution, but the residual soil after extraction was distinctly toxic to nitrifying flora. The work during the year under report was a detailed periodical study of the several water soluble and insoluble products formed on incubating calcium cyanamide with the refractive soils. Five soils from Cawnpore, Gujranwala, Peshawar, Dacca and Pusa were selected for the study and work with three soils, *viz.*, Dacca, Cawnpore and Gujranwala was in progress.

Effect of fertilisers on calcareous soils.—The optimum requirements of calcareous soils, as typified by the Pusa soil containing about 40 per cent of calcium carbonate, in nitrogenous, phosphatic and potassic fertilisers, were under investigation :—

(a) *Nitrogen.*—Ammonium sulphate on basal dressings of potassium sulphate *plus* superphosphate gave the largest yield of wheat in pot cultures when applied at 30 mg. nitrogen per kilo of soil. On the other hand, in field plots, increasing applications from 40-100 lbs. of nitrogen to the acre resulted in increasing response of

wheat, but the increment due to nitrogen was, however, not proportional. In regard to the composition of wheat grain, the nitrogen content steadily increased with increasing applications of this constituent to the field while the reverse was the case for the phosphate content of the grain. The reduction in the P_2O_5 content was, however, not proportional to the increase in nitrogen. The potash content of the grain was not appreciably affected by the increased absorption of nitrogen.

(b) *Phosphate*.—In pot cultures the maximum response of oats to super was with 30 mg. P_2O_5 per kilo of soil. Above this level the yield was almost constant. In field plots *ragi* (*Eleusine coracana*) gave somewhat similar results, the maximum yield being at the level of 70 lbs P_2O_5 per acre. The ash content of the *ragi* grain was not appreciably influenced at any level of fertiliser application in the range 50-100 lbs. P_2O_5 per acre, but its composition varied. Increasing doses of phosphate applied to the field were reflected by a definite, though not proportional, increase in the P_2O_5 content of the grain. There was a tendency on the part of nitrogen to decrease as the P_2O_5 content of the grain was increased but potash was not visibly affected.

(c) *Potash*.—In view of the general lack of response observed at Pusa and in several parts of India to potassic manures, pot cultures and field experiments were carried out with applications of potash in the form of sulphate, chloride and carbonate of potash. The response varied with the crop and season and the specific depressing effect of sulphate ion on crop yield was not consistent and definite. The results are being worked up for publication.

Availability of superphosphate in relation to depth of placement.—Further pot-culture experiments carried out during the year with *ragi* as the test crop, confirm the findings reported in the previous year. It has been found that super does not move beyond four inches from the region of its placement. In experiments with super placed at 3, 6, 9 and 12 inches depth, using *ragi* as the test crop, the best result was obtained with placements at 6 inches depth.

Relative availability of artificial and natural phosphates.—In the report for 1933-34 the tests on the availability of different natural and artificial phosphates applied to Pusa soil were reported. During the year under report the residual effects were measured. Several of the phosphates which showed low response in the previous year for direct application showed high residual effects.

Relationship between citric acid solubility of a phosphatic fertiliser and crop response.—Experiments were carried out to see if any correlation existed between the value for phosphate soluble in two per cent citric acid as determined in the laboratory and the crop response on calcareous Pusa soils as measured by yields from

pot-cultures. The results of experiments with some of the phosphates show no such relationship as will be seen from the table below of the results of pot experiments.

Phosphate	Solubility in 2% citric acid %	% Increase over control		% Growth variation in <i>ragi</i> seedlings over control
		Mustard (direct)	<i>Ragi</i> (resi- dual)	
Iron phosphate . . .	11.20	57.0	58.6	—27.5
Apatite . . .	12.08	22.3	16.6	25.5
Trichy phosphate . . .	23.24	32.2	1.3	—29.4
Dicalcium phosphate . . .	54.68	61.6	27.0	40.2
Superphosphate . . .	75.84	127.3	51.2	86.3
Mag. Ammon phosphate	81.47	56.2	7.0	—13.7
Aluminium phosphate . .	94.71	19.0	76.0	40.2
Bonemeal . . .	99.49	36.8	—20.9	88.2
Tri-calcium phosphate . .	100.00	62.8	69.4	104.0
Potassium phosphate . .	100.00	38.8	62.5	150.0
Ammonium phosphate . .	100.00	105.0	36.6	200.0
Sodium phosphate . . .	100.00	40.5	76.6	316.7

Solubilisation of Khudada phosphate.—Two composts of this insoluble phosphate were prepared and tested on the field scale. One compost (sand-sulphur compost) was made up of 'khudada' phosphate 100 lbs., sand 100 lbs., sulphur 25 lbs., charcoal 16 lbs., water 25 lbs.; the other (berseem compost) was made up of khudada phosphate 100 lbs., green berseem 100 lbs., sulphur 25 lbs. The matured composts were tested on the field scale along with the raw phosphate in a finely ground form. Khudada phosphate by itself contributed to an increase of 36 per cent of mustard crop while the sand and berseem composts gave 50 and 45 per cent respectively over control. The increased yield on account of compost is not likely to cover the cost of composting.

Experiments on green manuring.—In previous years it has been shown from laboratory experiments that the yield of wheat after applying sann-hemp tops alone is equal to that when the whole of the sann-hemp plant is buried in the soil. This gives the cultivator the advantage of fibre from the sann-hemp. The experiments were translated to the field scale with confirmatory results. The results of large scale experiments have shown that while the yields of wheat for sann-hemp whole plants versus tops alone were the same, the yield of fibre from the stems remaining after using tops as manure was 500 to 600 lbs. per acre. The full set of results and the economics of the problem will be fully discussed in a report which will soon be ready for publication.

Sugarcane manuring.—These experiments were continued according to the following scheme with the variety Co. 213.

- (1) 100 lbs. nitrogen as mustard cake + 20 lbs. K_2O + 45 lbs. P_2O_5 .

- (2) 100 lbs. nitrogen as mustard cake + 50 lbs. K_2O .
- (3) 100 lbs. nitrogen as mustard cake + 100 lbs. P_2O_5 .
- (4) 100 lbs. nitrogen as mustard cake + 50 lbs. K_2O + 100 lbs. P_2O_5 .
- (5) 100 lbs. nitrogen as molasses and Ammonium sulphate + 50 lbs. K_2O .
- (6) 100 lbs. nitrogen as molasses and Ammonium sulphate + 50 lbs. K_2O + 100 lbs. P_2O_5 .

The molasses used in the experiment contained 5.27 per cent K_2O , 0.50 per cent nitrogen and 0.23 per cent P_2O_5 . In the unmanured plots growth stopped by December, but the crop in the manured plots continued to grow till February. The final harvest and analysis results showed that the application of manures was justified economically. For 0.25 acre plots used in the experiment the yield of sucrose for complete manuring was 187 lbs. as against 104.7 lbs. for the plot receiving no manure. The combination of molasses, ammonium sulphate and super, omitting potash, gave as good a result as with mustard cake, potassium sulphate and super. The results are being worked for publication.

Preliminary investigation on certain types of barley seedlings susceptible to white-ant attack.—At the instance of the Imperial Economic Botanist a preliminary investigation was carried out on certain types of barley seedlings which were attacked by white-ants in different degrees of severity. Three types of plants, viz., type 2, type 21 and type 22 were selected. The damage occurred in the early seedling stage at the hypocotyl region and type 21 seedlings suffered most extensively. The original grains as well as the seedlings were germinated in trays and the sugar contents at the early germination stage and after the full development of the plumule were determined. The ash, silica and potash contents were also determined. Type 21 barley seedlings contained the largest amount of sugar, but the difference between this and the other types was not enough to explain the extent of damage. There was sufficient sugar in all the tender seedlings to attract white-ants. Further comparative analyses of the hypocotyl portions of attacked and unattacked seedlings revealed considerable differences in their ash and silica contents. While the unattacked ones contained only about sixty per cent silica on ash, the attacked ones contained only about forty-one per cent silica. This relatively low silica content and the consequent softness might have been the cause of the more extensive damage in type 21 seedlings.

3. MICRO-BIOLOGICAL

Slime producing organism in sugarcane juice.—It was observed that sugarcane juice kept for some time became slimy. Addition to the juice of water passed through Katadyn pellets or of water

in which Katadyn electroliser was allowed to pass current for one half hour did not prevent the development of the organism. The organism was isolated and studied. It is short and rod shaped and forms raised watery colonies on ammonium nitrate agar. Although slime is produced, the organisms are not capsulated. Glucose, lactose, saccharose, mannite, dulcitol, milk, glycerol, salicin, arabinose, maltose, levulose and raffinose are fermented without production of gas. The organism liquifies gelatine, but it does not produce indol nor does it reduce nitrate.

4. BACTERIOPHAGE OF ROOT NODULE ORGANISMS

Sann-hemp (*Crotalaria juncea*), cow pea (*Vigna catjang*), Mung (*Phaseolus radiatus*), Sweet pea (*Lathyrus adoratus*), Kerao (*Pisum arvense*) were under investigation to ascertain (1) whether bacteriophage occurs in all legumes and legume nodules, (2) if it occurs, whether it is the same or different in different types of nodules, (3) if different, whether they form the basis for the classification of nodule bacteria and (4) the relationship of the bacteriophage to the formation or otherwise of nodules.

Test with young plants did not indicate appearance of the bacteriophage in any of the types of plants experimented with. Periodical examinations as the growth of the plants advanced were, therefore, made with the following results:

	2 weeks	4 weeks	6 weeks	8 weeks
Sann-hemp	— — —	— — —	— — —	— — —
Cowpea	— — —	— — —	— — —	— — —
Mung	— — —	— — —	— — —	— — —
Sweet pea	— — —	— — —	— + +	+ + +
Kerao	not determined			+ + +

— — — = Nil.

— + + = Bacteriophage found after 2 or 3 filtrations.

+ + + = Bacteriophage found in the first filtrate.

These results, so far as they go, are at variance with those of Laird (1932) who observed that bacteriophage may be isolated readily from young nodules, with difficulty or not at all, from old ones. This will be further investigated.

The specificity of the bacteriophages in the production of lysis on solid medium of cultures by different species of organisms, individually and separately, was tested. Berseem (*Trifolium alexandrinum*), sweet pea and Kerao were the plants used. Berseem bacteriophage and Sweet pea bacteriophage touched cultures of berseem and Sweet pea organisms in direct and cross inoculations; while the bacteriophage from Kerao touched only its own organisms and had no effect on berseem or Sweet pea organisms.

Attempts to study the action of bacteriophage on growth of plants in glass bead cultures under sterile conditions, using soil

extract with 2 per cent marmite and 0.05 per cent were so far not successful.

Dissociation of Azotobacter in liquid medium.—The object of this investigation is to ascertain whether different forms of *Azotobacter* exist in soils, and if so, whether they fix nitrogen in an equal or varying degree as compared to the large globule or oval forms of *Azotobacter* in Ashby's mannite solution. By several transfers of a laboratory culture of *Azotobacter* in mannite-marmite broth at pH 7.8—five dissociative forms of the organism could be obtained on the fourth to sixth plate. The nitrogen fixing capacity of the different forms in Ashby's mannite solution was determined in quadruplicate. Description of the dissociative forms and the average nitrogen fixation values are given below:—

Organism.	Description.	Mgm. nitro- gen fixed. Average of 4 determina- tions after de- ducting value for control.
S. AZ	Large globules and ovals	3.40
D. F i	Small Cocci	0.22
D. F ii	Short rods with granules	0.12
D. F. iii	Coccal rods	—
D. F. iv	Cocci (medium)	0.05
D. F. v	Cocci (smaller)	0.05

5. FOODS AND NUTRITION

Silage experiments.—In continuation of the previous experiment, dub grass mixed with molasses to the extent of ten per cent was found to make a good silage.

Feeding experiments with bullocks and milch cows.—Feeding experiments were commenced with Sahiwal (Montgomery) bullocks and cows to ascertain the digestibility values of feeds and fodders used, and the suitability and adequacy or otherwise of the ration fed to milch cows. With a ration of rape cake as the concentrate and oat straw as roughage, the percentage digestibility values were: dry matter 59.5; protein 51.9; fat 57.3; fibre 75.7; minerals 43.7. With rape-cake and maize silage the digestibilities were: dry matter 59.0; protein 58.4; fat 80.1; fibre 65.0; minerals 44.6. Work with other feeds and animals and on the protein requirements of work and milk animals was in progress at the end of the year under report. The data are not yet ready for discussion.

6. INDUSTRIAL PROBLEMS RELATED TO AGRICULTURE

This part of the report deals with work calculated to evolve simple methods and processes suitable for the industrial and commercial utilisation of agricultural produce and waste. A beginning was made during the year under report and will be continued as opportunities are available.

Butter experiments.—Comparative experiments were conducted to test the flavour produced by organisms isolated at Pusa and with imported cultures. Among the isolations so far made, culture No. 6A produces butter of quality comparable with that produced with cultures Nos. 27 and 29 of Hammer. The isolation of flavour producing organisms from Aligarh butter was in progress.

Activated carbon from paddy husk.—Paddy husk and chaff and similar husks from other cereals are waste products in agriculture and if these could be turned to useful account it will be to the advantage of the cultivator. The possibilities of making activated carbon from paddy husk was under investigation with promising results. Activated carbon is useful in the manufacture of *gur*, white sugar and sugarcandy by the Open-Pan system and in refining oils. At present active carbons are imported from abroad at Rs. 1,000—Rs. 1,500 per ton. A simple process has been evolved for the production of active carbon which possesses properties similar to the imported carbon. The process is very cheap and simple and does not require elaborate equipment. The whole process has been so simplified that if necessary, the active carbon can be manufactured with the equipment available in a village or town and without the use of mineral acids and alkali hydroxides and by a person of average intelligence and at a tenth or even lower than the cost of the imported product.

The absorption and physico-chemical properties of the activated carbon produced were under study with a view to understand its behaviour in the clarification of sugarcane juice in the Open-Pan system of manufacturing *gur* or white sugar. The new product possesses the property of clarifying sugarcane juice to water white colour and of absorbing other suspended and dissolved impurities. It absorbs organic acids. In a typical experiment with acetic acid, the concentration of acid in solution at the equilibrium stage gave on plotting a parabolic curve. The carbon absorbs anions from inorganic salts followed by an increase in the pH of the solution. Potentiometric titrations do not show a sharp break anywhere in the region of pH 7 indicating that the carbon is capable of acting as a buffer. This property is very useful in the boiling of sugarcane juice.

The use of active carbon in the clarification of sugarcane juice for *gur* and sugar manufacture.—Active carbon prepared as above from paddy husk was successfully employed in clarifying sugarcane juice for the manufacture of *gur* and sugar by the Open-Pan method. A simple technique worked out for the treatment of juice and *gur* and better quality products were obtained from the local market. Besides clarifying and decolorising juice to water white colour, treatment with active carbon raises the purity of juice by three or four units. In experiments with a variety of cane Co. 299, the purity rose from 82.36 to 86.01. Treatment with active carbon

has also the property of checking inversion in the boiling of the clarified juice. For instance, gur made from Co. 281 cane juice without clarification with carbon contained 80.2 per cent sucrose and 4.3 per cent glucose, while the gur from carbon treated juice contained 86.2 per cent sucrose and 2.36 per cent glucose. White sugar comparable in colour and quality, to good factory made sugar can be obtained by the Open-Pan method by treatment with lime for clarification and for preventing inversion. The lime is then removed by phosphoric acid. The juice is then decolorised with active carbon and boiled. Gur prepared by the active carbon process possesses better keeping qualities than the best quality ordinary gur.

7. MISCELLANEOUS AND GENERAL ANALYTICAL WORK.

Investigations on the running of gur on storage, the composition and malting values of different types of barleys, on preserving indigo pastes and their leuco compounds were in progress. The results have not yet reached the stage for discussion.

General consultative and analytical work.—This is a very useful and important branch of the Section and worked at a high pressure during the year under report. In addition to answering several consultative references of a highly scientific and practical nature received from official and non-official sources, the following samples which were submitted to the Section, were analysed and reported upon :—

Soils	25
Manures and fertilisers	57
Oil seeds	12
Sugarcane and beet	387
Food stuffs and fodders	4
Ganja	3
Tobacco	7
Water	5

Several of the samples were from the Heads of Sections of the Institute in connection with their researches and from the North-West Frontier Province, Baluchistan and Coorg. There were many samples from non-official bodies.

Among samples examined, mention may be made of the following on account of their scientific or economic interest.

The composition of samples of filter press mud from Indian sugar factories was as below :—

	per cent.
Water	60—70
Organic nitrogen	1.03—1.09
Phosphoric anhydride	3.8
Potash (K_2O)	0.4—1.03

The Director of Agriculture, North-West Frontier Province, sent samples of dried blood in which varying proportions of lime were mixed with the blood before drying. Lower nitrogen values were obtained for samples with 3 per cent lime, due evidently to loss of nitrogen as ammonia. The use of powdered charcoal instead of lime was suggested.

Samples of tobacco-tomato and tomato-tobacco grafts made by the Imperial Economic Botanist contained the following amounts of nicotine :—

Tobacco stock	9.3	per cent nicotine
Tomato scion	1.27	„
Tomato stock	Nil	
Tobacco scion	0.35	„
Ordinary non-grafted tobacco	3.36	„

Nicotine appears to migrate from tobacco stock into the tomato scion, but not from tobacco scion to tomato stock. For the bio-chemist these results are interesting from the point of view of plant metabolism and will be pursued. Samples of wild tobacco and *N. tabacum* leaves contained 0.07 and 0.71 per cent of nicotine respectively.

Samples of sugar beet were sent from Peshawar carefully packed in a deal wood case in the month of May. The external appearance and the composition of the juice indicated deterioration. The roots lost their turgidity and yielded juice with a dark colour. Treatment with activated paddy husk charcoal prepared in the laboratory completely decolorised and yielded a bright colourless juice. This is interesting as being indicative of the possibilities of developing beet *gur* and beet-sugar as small scale agricultural industries.

Samples of Seville oranges from Peshawar were analysed with the following results :—

Average weight of fruit	6.77	oz.
Juice on the weight of fruit	39.68	per cent.
Oil bearing rind on the weight of fruit	41.69	„
* * * * *		
Acid as citric acid—		
On weight of fruit	1.32	per cent.
„ juice	3.45	„
Oil finest quality—		
On weight of fruit	0.19	„
„ rind	0.46	„
Oil heavy quality—		
On weight of fruit	0.10	
„ rind	0.25	

Ashes from *adhatoda* (*adhatoda vasica*) plant sent by the Director, North-West Frontier Province, appear to be a good source of potash as will be seen from the results of analyses given below :—

	per cent.
Lime (CaO)	28.0
Magnesia (MgO)	10.6
Potash (K ₂ O)	12.8
Phosphoric anhydride	1.8

An interesting sample was that of a sugarcane crop which continued to stand in the field for the second year. It is not usual in India to keep a sugarcane crop for two years, and so far, no periodical analyses of such a crop have been recorded. The date on monthly analyses of samples sent in by the Imperial Agriculturist are given in full.

Composition of the juice of sugarcane Co. 210 during its second year of growth.

(Crop planted early in 1933.)

Laboratory No.	Date of analysis.	Average weight of a cane. lb.	Per cent. Juice expressed.	Brix (Corrected).	In juice.		
					Sucrose. %	Glucose %	Purity. %
1934							
107	8-2-34	1.63	65.39	17.94	15.45	0.24	86.11
352	28-5-34	1.65	65.45	20.41	17.40	0.78	85.27
372	12-6-34	1.86	65.77	19.60	16.84	0.68	85.90
373	27-6-34	1.48	65.30	18.57	15.82	0.62	85.19
375	17-7-34	1.79	69.23	18.44	15.99	0.56	86.75
417	14-8-34	1.66	78.93	18.28	15.74	0.49	86.11
423	28-8-34	1.50	64.20	18.64	16.11	0.39	86.42
437	11-9-34	1.50	. .	16.97	14.65	0.46	86.37
454	25-9-34	1.80	66.00	17.28	14.90	0.38	86.26
455	11-10-34	1.37	62.72	17.08	14.65	0.41	85.77
486	26-10-34	1.53	60.66	18.80	16.26	0.52	86.51
506	14-11-34	1.53	60.87	16.97	15.12	0.46	89.10
1935							
1	5-1-35	1.52	65.94	17.20	15.02	0.18	87.83

The history of the samples was not known till the rounds of analyses were over. Otherwise the top-bottom ratios would have been determined and these would have thrown light on the second year's life history of the crop. The condition of the crop throughout the period was abnormally good. All through, the average weight of a single cane was maintained. The purity of juice was maintained high. It had increased from November 1934 to the end of January

1935. From the end of June to the end of October, sucrose in juice decreased somewhat but it rose again. The weather conditions were unusually favourable. There were rainfalls in January 1.96 in., in February 0.57 in., March 0.42 in., June 7.24 in., July 15.27 in., August 15.27 in., September 4.50 in., October 2.76 in., and in November 0.43 inch. The maximum temperature in shade was never more than 108° F., being 107° F. for five days and 108° F. for three days. So there was nothing like drought and drying up of soil, for the cane to dry up quickly and deteriorate.

For the Imperial Mycologist several comparative analyses of normal and borer attacked Co. 213 variety of canes and samples from mosaic experimental plots were analysed. For the Imperial Entomologist samples of Co. 214 and Co. 331 canes, normal and canes damaged by stem, shoot and root borers were analysed. Judging from the composition of the juice it would appear that shoot and stem borers are decidedly more detrimental than the root borer. Juice from root bored cane analysed distinctly better than the normal. In regard to the other two kinds of stem borers, juice from affected canes was poorer in Brix by 2 to 4 per cent, in sucrose by 2 to 5 per cent and in purity by 3 to 12 per cent. From an examination of the split canes, it would appear that the large deterioration in the quality of the juice was due more to the activity of yeasts, and alcoholic fermentation which was distinctly in evidence.

The use of carbon tetrachloride as a solvent in determining the specific rotation of ganja resin was found to give a hazy solution which does not give a sharp demarcation of light and shade in the polariscope. Anhydrous petroleum ether was found to give a clearer extract and consequently more accurate polariscope reading. Extraction with carbon tetrachloride gave a higher amount of soluble matter than petroleum ether, but the specific rotation was found to be lower with the former solvent in two cases out of three.

Sample No.	87/1935		88/1935		89/1935	
	In CCl ₄	In petrol ether.	In CCl ₄	In petrol ether.	In CCl ₄	In petrol ether.
Sp. Rotation .	—141.80	—143.28	—172.02	—203.80	—157.43	—148.17
Resin per cent.	13.60	11.76	15.05	13.56	14.80	13.44

VI. PROGRAMME OF WORK FOR 1935-36

1. The move of the laboratories to Delhi.
2. The completion of the programmes on hand at Pusa.
3. Soil survey and study of the cultivable area of the new Institute at Delhi.
4. Post-graduate training.

VII. CONTRIBUTIONS AND PAPERS FOR PUBLICATION

The following articles were contributed by Mr. B. Viswa Nath:—

1. Presidential address on soil work in India, for the Indian Society of Soil Science.
2. Draft of All India Fertiliser Act for the Imperial Council of Agricultural Research.
3. Notes on All-India soil survey, methods of soil analyses and present position of statistical interpretation of field experiments, for the Board of Agriculture.
4. Review on Agricultural Chemistry in India in 1931-32 and 1932-33, for the Imperial Council of Agricultural Research.
5. Review on Thirty-years' Manurial experiments in India, for the Imperial Council of Agricultural Research.
6. Discussion on the "Methods for testing the degree of ripeness of Sugarcane," for the Congress of International Society of Sugarcane Technologists, Brisbane.

Publications.—The following papers were submitted for publication:—

1. The manurial value of different phosphates in calcareous soil, by S. Das.
 2. Studies on the dissociation of *Bacillus cereus*, by N. V. Joshi and S. C. Dutt.
 3. An aroma producing lactic acid organism isolated from Indian dairy products, by N. V. Joshi and C. S. Ram Ayyar.
 4. Studies in the chemistry of sugarcane:—The Top-Bottom Ratio method of determining the degree of ripeness, by B. Viswa Nath and S. Kasi Nath.
 5. Report on investigations on a new and simple process for the manufacture of active charcoal from paddy husk and on the manufacture of "Cream Jaggery" using active carbon, by B. Viswa Nath.
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REPORT OF THE IMPERIAL MYCOLOGIST

(L. D. GALLOWAY, M.A.)

(1) MYCOLOGICAL SECTION, PUSA

I. ADMINISTRATION AND STAFF

Dr. M. Mitra was in charge of the Section until December 17th, 1934, when Mr. L. D. Galloway took over the post of Imperial Mycologist.

Mr. H. H. Prasad, previously Assistant in the Bacteriological Section, was transferred to this Section from November 1st, 1934.

II. TRAINING

Mr. S. C. Chowdhury, B.Sc. (Ag.), joined the Section for post-graduate training from January 2nd, 1935.

Mr. R. S. Mathur, M.Sc., a post-graduate student of Lucknow University, worked in the Section from 9th October to 11th November 1934, and Dr. J. K. Dubey, Assistant Director of Agriculture, Bhopal, during portions of January, February and March 1935.

From March 1st to 8th, 1935, three post-graduate dairy students, W. D. E. Perera, N. K. Jadhav, and C. Ekambaram, were under instruction in certain aspects of mycology.

III. DISEASES OF CROP PLANTS

(i) WHEAT

Loose Smut.—Solar heat methods have recently been recommended for the control of loose smut (Luthra and Sattar, *Ind. J. Agric. Sci.* 1934 4, 177-199). Experiments carried out during the past year show that these methods can be applied with good results in Bihar, where the sun temperature rises to 130° F. on bright summer days.

Wheat seed of Punjab 8A, with a heavy natural infection, was treated on a suitable day in summer by the two following methods:—(1) seed soaked 8 A.M. to noon, then drained and exposed to sun's rays from noon to 5 P.M. (2) Water contained in a blackened metal drum was exposed from 8. A.M. to noon; seed was placed in the water, and exposure to the sun's rays continued from noon to 5 P.M. The treated seed was dried and stored until November. On another day a second lot of seed was given the above treatments.

At the time of maturity, the percentage of smutted heads in the replicated plots of untreated seed ranged from 1.54 to 2.03 per cent. Not a single smutted ear was found in any of the plots of treated seed.

Solar treatment was also given to 258 maunds of heavily infected seed at Karnal; no untreated control was possible, but there is strong evidence that the incidence of smut was greatly reduced by the treatment.

Bunt.—Previous observations have indicated that bunt does not develop under Pusa conditions. This has been confirmed during the present year. Grain of Pusa 4 and P. 165 was given a heavy artificial infection with bunt spores, germinated in sand in a cool incubator, and the seedlings were transferred to a plot in Pusa. At the time of harvest there were 1007 ears of P. 4 and 1075 of P. 165, but none showed any sign of bunt. Infected seed of P. 4 was also sown in pots in January 1934, that is, when the temperature was most favourable for germination of bunt spores. The plants raised from this seed also showed no trace of bunt.

An experiment to test the efficacy of various fungicides in controlling bunt was again carried out at Karnal, naturally infected seed of Pusa 114 being used. Six replications were sown, of seed given the following treatment:—(1) control (2) hot water (3) solar heat (4) wet treatment with Uspulun, and dry treatments with (5) Ceresan (6) Granosan (7) copper carbonate, and (8) charcoal and formaldehyde.

The hot water treatment was very successful and has the added advantage of controlling loose smut; solar heat was less successful. Uspulun presents no advantages over the mercury dusts, and in any case, is now withdrawn from the market.

For fifty bunted ears collected at random, the length of ear and the number of spikelets were noted, and compared with fifty normal ears. The infected plants showed a clear reduction in both these characters. This year the presence of completely bunted ears was observed for the first time.

There is evidence that bunt infection is soil borne as well as seed borne. In May 1933 certain plots at Karnal showed 10-15 per cent bunt infection. Eighteen months later seed which had received treatment with a fungicide was sown in these and other plots, and only developed bunt in these plots where bunt had previously occurred. This point is being studied further, but it seems clear that a one year rotation is not sufficient.

Rust.—All three rusts were observed a trifle earlier than usual, the dates for first recorded appearance at Pusa being

December 9th for orange rust, January 7th for yellow rust and January 31st for black rust.

The chief varieties affected in the Botanical Area were Pusa 12 and P. 101, which showed fairly severe attack by orange and black rusts, and in the case of P. 101 yellow rust also.

As in previous years, an estimate was made of the percentage of leaf area covered by orange and yellow rusts; in the table below similar figures for *Helminthosporium* (*H. sativum* P. K. and B. and *H. tritici repentis* Died.) are included for comparison.

Variety	Orange	Yellow	<i>Helminthosporium</i>
P. 4	Trace	<i>Nil</i>	24.0
P. 12	14.9	Trace	3.2
P. 52	2.3	1.1	17.5
P. 80.5	2.7	<i>Nil</i>	22.6
P. 101	8.8	11.3	15.9
P. 111	Trace	<i>Nil</i>	18.4
Local	2.1	Trace	6.5

Black rust was most severe on P. 101, moderate on P. 12, and slight or absent on the remaining varieties.

At the Botanical Sub-Station, Karnal, rust was almost absent this year. P. 52 was not sown on a field scale, but as usual showed fairly heavy attack by yellow rust.

Aeroscope slides exposed at regular intervals from October 15th, 1934, to March 15th 1935, and also fresh specimens of wheat and barley rusts, were supplied to Dr. K. C. Mehta, Agra, in connection with his rust research work.

Black Point.—A large number of wheat grains collected at Pusa showed the burnt and brownish appearance known as "black point". Shrivelling of the grain and discoloration of the glumes sometimes accompanied the disease. On isolating the fungi responsible, seventy per cent of the seed was found to contain *Helminthosporium sativum*, whilst others showed *H. tritici-repentis*, *Alternaria* sp., and *Fusarium* sp. The mycelium occurred within the seed-coat, and surface sterilisation did not destroy it. This is the first record of "black point" at Pusa.

Foot-Rot.—A foot-and root-rot of wheat seedlings was found to be associated with the presence of *Fusarium* sp. and *Rhizoctonia* sp., the former being more common. Specimens received from Sabour also showed attack by *Fusarium*.

Mildew.—*Erysiphe graminis* Lev. was fairly common this season at the Botanical Sub-Station, Karnal.

(ii) OATS

Covered Smut.—An examination was made of samples of smutted oats—received by courtesy of the Departments of Agriculture concerned—from 24 areas in Bihar, U. P., Punjab, Sind, and North-West Frontier Province. The results confirmed the statement made in last year's report that the predominant smut in Northern India is covered smut, *Ustilago kollerii* Wille, and not loose smut, *Ustilago avenae* (Pers.) Jensen.

The dry spray method of applying formalin to smutted oat seed was again given a trial this year. Seed for nearly 100 acres was treated at Karnal in October, two to three weeks before sowing. The resulting crop was practically free from smut, infection being below 0.01 per cent as compared with 4 per cent of previous years.

In collaboration with the Botanical Section, a trial was made of the relative resistance to smut of sixty oat types developed at Pusa. Seeds of oat differentials for identifying the physiological forms of covered smut were also obtained by courtesy of Dr. G. M. Reed of Brooklyn and Miss K. Sampson of Aberystwyth. Unfortunately all the oat types remained free from smut, so presumably the smut spores used for infecting the seed failed to germinate. The reason for this is being investigated.

(iii) BARLEY

Helminthosporium disease.—*H. teres* Sacc., first noticed at Pusa in 1930, was altogether absent during the year, possibly owing to treatment of the seed with mercury compounds.

The percentage of leaf area destroyed by *H. sativum* was recorded for 24 types of Pusa barleys, and was found to vary from 1.46 to 10.82 per cent. The range for type 21 grown in nine different areas at Pusa was from 1.68 to 7.83 per cent; the variation appears to be due to time of sowing as well as to locality.

Foot-rot of barley was very bad in plots where barley is grown year after year, and in plots where no seed treatment was given. Experiments carried out with various fungicides show that good control of foot-rot and root-rot caused by *H. sativum* can be obtained by the use of mercury compounds. Such treatments, however, do not prevent secondary infection of the more mature plants by spores from neighbouring fields of wheat and barley or from certain wild grasses which can also act as host. This work has been written up for publication.

(iv) RICE

Sclerotial diseases.—Field and pot experiments were again repeated during the year to test the parasitism of *Leptosphaeria salvinii* Catt. (= *Sclerotium oryzae* Catt.). Seedlings of rice type 31 were transplanted early in July to pots and plots, both heavily

infested with the fungus. The plants developed normally and bore well filled panicles. The dried up straw after harvest showed the presence of sclerotia, indicating that development of the fungus had taken place, although, as last year, it had failed to produce any disease symptoms in the plants. The investigation has been written up as a paper, the general conclusion being that this fungus is not a serious parasite under Pusa conditions, nor, so far as present information indicates, under east or south Indian conditions generally.

False Smut.—A quantity of panicles attacked by *Ustilaginoidea virens* (Cke.) Tak. was collected in December 1933 at Maruteru in the Godavery district. This infected seed was grown in pots of normal soil, and healthy seeds were grown in pots of infested soil obtained by mixing the soil thoroughly with infected panicles. In neither case did the resulting plants show any false smut, confirming the records of previous workers that this disease is not seed or soil borne.

(v) SORGHUM

Colletotrichum.—Various seed treatments were tried on *Jowar* for the control of *Colletotrichum graminicolum* (Ces.) Wilson. Mercury compounds, formalin, and solar heat treatment were all ineffective. This is in agreement with the results of some previous workers, but not with those of others.

(vi) TOBACCO

Black Shank.—In December 1933 a severe root-rot disease of tobacco was observed at Anakapalle in the Vizagapatam district. The symptoms were those of the Black Shank disease of tobacco recorded in America, and examination of the diseased plants revealed the presence of a *Phytophthora*. The Government Mycologist, Madras Presidency, states that this disease had been observed by him in 1930, and regarded as the Black Shank organism, *Phytophthora parasitica* var *nicotianae* Tucker. The present isolations have been compared with authentic Black Shank organisms obtained from workers in Florida and Java respectively, and although somewhat slower in growth, appear to agree well with these cultures.

Experiments carried out in sterile soil show that the Madras *Phytophthora* is a virulent parasite. Under Pusa conditions mortality was low or *nil* in the winter months, but from April to October seedlings transplanted to infected soil show a very high proportion of deaths.

Phytophthora parasitica Dast. isolated from *Ricinus*, and *P. palmivora* Butl. from coconut palm were unable to attack transplanted and mature plants. Under these conditions, *Pythium aphanidermatum* (Edson) Fitz. was also not pathogenic, though this species has previously been shown capable of producing a root-rot in tobacco.

Further studies are in progress on the identity and morphology of the Black Shank fungus, its toxin production, possible control by fungicides, and the relative resistance offered by different tobacco varieties.

Root-rot.—From diseased roots of tobacco two strains of *Fusarium* were isolated. Attempts to establish the pathogenicity of these organisms by mass-infection of soil in which tobacco seedlings were then planted proved unsuccessful.

(vii) POTATO

The investigation of suitable potato types for Northern India has been taken up by the Botanical Section. As susceptibility to fungal diseases and to the virus diseases bringing about degeneration is an important factor in this connection, the Mycological Section is collaborating in this work. So far only preliminary work has been done, but observation of last year's crop at Pusa has shown that the following diseases are important. (1) Tip or Hopper Burn, (2) *Alternaria* blight, (3) *Rhizoctonia* rot, and possibly also *Fusarium* wilt, (4) Leaf roll, streak, crinkle, and other mosaic diseases.

On the tubers themselves Scab *Spongospora subterranea* (Wallr.) Johnson, and sclerotia of *Rhizoctonia solani* Kühn. have been noticed, while *Fusarium oxysporum* Schelt. has been isolated from rotted tubers. Bacterial rot is common in storage and one of the types commonly found agrees with *Bacterium solanacearum*. Symptoms resembling internal rust or "Spraing" have been observed, but no confirmation could be obtained of the view that this disease is caused by a micro-organism.

(viii) PIPER BETLE

Foot-Rot.—It has been found that Phenyl may be used instead of Kerol for controlling foot-rot in *Pan* due to *Sclerotium rolfsii* Sacc., and *Rhizoctonia solani* Kühn. Phenyl is more readily obtainable but requires to be used in a more concentrated solution; this is in agreement with laboratory experiments showing that Kerol has roughly four times the inhibiting power of Phenyl. Pot experiments are being repeated this year to confirm the lowest effective concentrations of these antiseptics, and to try other possible substances.

(ix) CINCHONA

Seedling disease.—A serious disease of cinchona seedlings was first observed in the Darjeeling district in 1928. The collar is attacked, and the discoloured area gradually extends upwards until it reaches the cotyledons which become limp and bend over. The leaves turn yellow and curl inwards and in some cases they are shed. A species of *Phytophthora* was found to be present in

diseased seedlings, and inoculation experiments have proved its pathogenicity. The morphology of the fungus, its systematic position, and its ability to infect other hosts, have been written up and the paper is in course of publication.

(x) MISCELLANEOUS FRUITS AND VEGETABLES

Asparagus.—A stem disease of *Asparagus* noticed at Pusa has been investigated. Light brown patches are formed on the stem, which eventually becomes dry and brittle, with small dark pycnidia on the discoloured areas. The organism, a species of *Phoma*, has been isolated and its pathogenicity confirmed by inoculation experiments.

Grape vine.—A white rot disease of grape vine has been observed at Pusa. The stem and leaves of affected plants become brown and shrivelled and pycnidia are formed; in advanced cases the berries become brownish grey and slowly dry up. The systematic position of the organism concerned is still under study but it appears to be a new species of *Coniella*. The one-celled conidia are borne all round the inner surface of the pycnidia; they are hyaline when young and dark brown when mature. The perithecial stage also occurs. Inoculation experiments show that infection can take place through wounds.

Fruit trees.—An account of fruit tree diseases collected in Baluchistan has been written up and is being submitted for publication.

It has not been possible to make any tour of fruit growing districts during the year, but over a hundred specimens of fruit diseases have been received for examination and advice.

Tomato.—Wilted tomato plants were received from the Balasore district of Orissa, and the wilt was shown to be due to *Bact. solanacearum*.

Brassica spp. Bacterial rots of cauliflower, cabbage and turnip were observed at Pusa during March, and the study of these will be continued next winter.

IV. MISCELLANEOUS

Helminthosporium.—A fungus found to be the cause of a seedling disease of sugarcane has been found to agree closely with *H. halodes* var. *tritici* Mitra, previously recorded on wheat in India. In addition to this species and *H. sacchari* Butl. a third species of *Helminthosporium* occurs on sugarcane, and its morphology is being studied.

From *Euchlaena mexicana* a species of *Helminthosporium* was isolated which appears to be *H. maydis* Nishikado or a related species.

Colletotrichum.—A large number of *Colletotrichum* strains from various pulses are being examined and compared. There would appear to be several distinct species of this genus occurring on

pulses. A strain isolated from mid-rib of maize has been shown to be pathogenic, and is being compared with known species occurring on grasses.

Rhizoctonia.—Two isolations of sclerotial forms from betel vine show considerable differences from the usual species of *Rhizoctonia*, and are being studied further.

Small plot experiments were made with wheat seedlings to determine whether attack by white ants preceded or followed *Rhizoctonia*. The results require confirmation, but suggest that in cases where signs of both *Rhizoctonia* and insect attack are found, it is the latter which has occurred first.

Phytophthora.—The stimulation of oospore production in certain strains of *Phytophthora* by growing in association with another strain is well known. In order to determine whether this is due to chemical stimulation as opposed to heterothallism, an unheated filtrate (Chamberland filter) from a paired culture of *P. meadii* McRae and *P. colocasiae* Raciborski (strains not producing oospores) that had formed oospores was added to quaker oat agar, and plate cultures of these species were grown separately. *P. meadii* in the presence of the filtrate formed amphigynous oospores at 23°C. At this temperature, *P. colocasiae* formed no oospores, but at the higher temperature of the laboratory a few were formed. The experiments are being continued with filtrates of pure cultures and with heated filtrates.

A species of *Phytophthora* causing fruit rot of *Polyalthea longifolia* has been isolated, and its pathogenicity demonstrated. Cross inoculations with this and *Phytophthora parasitica* from castor gave positive results.

New records.—The following records are, so far as is known, new for India :—

Kawakamia sp., from *Cyperus tegetiformis* at Pusa. The fungus agrees with *K. cyperi* (Miy. et Ideta) Miyabe, but attempts to grow it in culture have failed.

Puccinia Prostii Moug., from *Tulipa* sp. received from the Agricultural Officer in Baluchistan. The spiny teleutospores are very characteristic.

Cystopus candidus (Pers.) de Bary from *Merremia emarginata*.

Soil Fungi.—A number of different soils from Pusa, and two from other sources, have been examined by the plating-out method. From samples taken during the first half of the year, the main points noted are :—

- (1) The predominance of *Aspergillus*. Ascosporic strains of *A. nidulans* occur in all samples, and *A. niger*, *A. terreus* and *A. ustus* are also common.

- (2) *Penicillium* and *Mucorales* are less common than in temperate climates—the former probably on grounds of temperature, and the latter on grounds of moisture.
- (3) *Cladosporium* and *Fusarium* are very frequent as in most soils.
- (4) The usually abundant soil types *Trichoderma* and *Asp. fumigatus* have not so far been encountered, although the former occurs as a saprophytic growth on sugarcane.

Other isolations include *Rhizopus arrhizus*, *Cunninghamiella* sp., *Chaetomium indicum*, *Alternaria* spp., *Helminthosporium sativum*, *Acrothecium lunatum*, *Phoma*, *Melanconium*, *Byssoschlamys*, and *Trichosporium*.

Soil temperature.—Soil temperature at depths of six inches and twelve inches have again been recorded throughout the year. This record has now been discontinued.

Fungicides.—Tests have been started to determine the possibilities of some of the newer organic antiseptics for seed treatment, sprays, or soil disinfection. Malachite green shows promise, and is not prohibitively expensive.

The antagonistic action of *Trichoderma* to certain pathogenic soil fungi has also been confirmed.

Seed treatment.—The following seed treatments were carried out for the Botanical Sub-Station at Karnal: in October 1934, 227 maunds of wheat were given hot water treatment, and 75 maunds of oats were sprayed with formalin; in May-June 1935 803 maunds of wheat were given hot water treatment.

Herbarium and Cultures.—During the year 83 herbarium specimens have been added to the collection, 18 of these being received from outside sources. Revision of the herbarium list is now almost complete. Work on identification of half named specimens has been continued.

About 60 specimens and cultures have been sent out in response to requests from other workers.

Identification and advisory work.—Over 200 specimens, half of these being fruit diseases, have been received during the year from the provincial Departments of Agriculture, the Universities, and from other sources. These have been reported on, and where necessary advice has been given regarding control measures.

Dr. K. D. Bagchee, Mycologist to the Forest Research Institute, visited the Section from April 15th to 30th, 1935, and help was afforded him with identifications.

Miscellaneous.—The section on plant diseases for the Review of Agricultural Operations in India 1931-1933 was written by Dr. M. Mitra at the request of the Imperial Council of Agricultural Research.

Two papers were read by Dr. M. Mitra, and one by Dr. B. B. Mundkur, at the Indian Science Congress held at Calcutta in January 1935.

V. PROGRAMME FOR 1935-1936

The necessity for improvised laboratory accommodation since the earthquake of January 1934, though causing a certain amount of discomfort and difficulty to the workers concerned, has not appreciably retarded the progress of the work in hand. The coming year, however, will be marked by preparation for the transfer of the laboratory to Delhi, and some dislocation of research work will be unavoidable.

The programme as contemplated at present includes the following :—

1. Studies on cereal smuts'
2. Foot-rot diseases of cereals
3. Control of foot-rot diseases of *Pan*
4. Virus and other diseases of potato
5. Comparative study of *Colletotrichum* strains from pulses and cereals
6. Black-shank disease of tobacco
7. Study of the fungus-flora of soils
8. Test of fungicides for seed treatment and soil disinfection
9. *Phytophthora* investigations
10. Study of fruit diseases
11. Investigations on various fungal and bacterial diseases of minor importance.

VI. PUBLICATIONS

- Kheswalla, K. F.. . . . Seedling Blight of Cinchona caused by *Phytophthora palmivora* Butl. in the Darjeeling District. *Ind. J. Agric. Sci.* 1935, 5: 485-495.
- Mitra, M. Stinking Smut (Bunt) of wheat with special reference to *Tilletia indica* Mitra. *Ind. J. Agric. Sci.* 1935, 5: 51-74.
- Mitra, M. and Bose, R. D. . . *Helminthosporium* diseases of Pusa barleys and methods for their control. *Ind. J. Agric. Sci.* 1935, 5: 450-484.

- Mundkur, B. B. Parasitism of *Sclerotium oryzae*. Catt.
Ind. J. Agric. Sci. 1935, 5: 393-
 414.
- Do. The Influence of Temperature and
 Maturity on the Incidence of
 Sann Hemp and Pigeon Pea Wilt
 at Pusa. *Ind. J. Agric. Sci.*
 1935, 5: 609-618.
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(2) SCHEME FOR RESEARCH ON MOSAIC AND OTHER DISEASES OF SUGARCANE

(Financed by the Imperial Council of Agricultural Research, 1934-35)

I. CHARGE

Dr. S. V. Desai remained in-charge until January 31st, 1935, when he left to take up the post of Bacteriologist, Agricultural College, Lyallpur. Pending the appointment of a successor to Dr. Desai, the duties of Sugarcane Mycologist have been taken over by the Imperial Mycologist in addition to his own duties.

II. MOSAIC DISEASE OF SUGARCANE

DISTRIBUTION

Mosaic has been observed for the first time on the following two varieties :

Co. 371 (Sepaya),

Co. 395 (Pusa, few. clumps only).

Other susceptible varieties have been given in previous annual reports.

A survey was made in July 1934 of six estates in North Bihar to estimate the percentage of mosaic infection in field cane. The results are given in the table below, and the percentages recorded during similar surveys in three previous years are attached for comparison :

Variety	1934			Percentages in		
	Total area examined (acres)	Number of localities included	Percentage mosaic infection	1927	1931	1932
Co. 213 .	20.92	6	0.12	0.03	0.2	0.58
Co. 210 .	1.84	4	0.26	0.5	0.96	0.09
Co. 285 .	1.3	3	0.34	..	..	0.12

NATURAL SPREAD

The following 24 varieties: Co. 210, 213, 214, 285, 299, 312, 313, 331, 342, 349, 351, 356, 387, 388, 393, 395, 396, 397, Tuc. 393, Tuc. 472, Uba, Saretha, P. O. J. 2878 and Lalgirah, were grown with alternate rows of mosaic-infected Co. 213. All varieties remained free from infection except for Co. 395, in which two clumps out of 120 developed mosaic. During previous seasons this variety has remained free from infection.

TONNAGE EXPERIMENT

The tonnage experiment at Pusa was carried out on the line laid down in previous seasons. The land was a good sandy loam but unfortunately the earthquake of January 1934 interfered considerably with the progress of the experiments. Fissures appeared in the plot, and owing to breakage of pipes the water supply was cut off for some time. Consequently the usual crude oil emulsion treatment could not be given, and the cane suffered severe attack by white ants.

The plan of the experiment was as follows: The plot, which had received green manure the previous season; was well levelled, and superphosphate and rape cake at the rate of 40 lbs. and 10 maunds per acre respectively were applied before sowing. 36 plots, each 5×56 yards, were laid out in adjacent pairs, sown with mosaic-infected and healthy canes in the order H. M. M. H. etc. Setts of Co. 213 were sown in the last week of February 1934, and germination was good in all plots; there was no spread of the disease to the healthy plots.

Later observations on the extent of insect attack were made by the staff of the Imperial Entomologist, and the mean differences were found not to be statistically significant. Some "Yellowing" of the leaves appeared in August, but on the soil being given cultivation the plants soon recovered.

Analysis of the plots was carried out during the last week of February 1935. On the advice of the Statistician only plots Nos. 13 to 32 were taken for the experiment and the rest rejected. A margin of 3 yards on each side was also rejected so that the size of the plot was reduced to 5×50 yards.

Ten feet of cane from each line, i.e. 50 feet from each plot, was taken for analysis, which was carried out by the Imperial Agricultural Chemist.

TABLE I
Samples taken from 11th to 14th February 1935.

Plot	No. of canes		Weight of canes and juice in pounds				Percentage extraction		Brix corrected		In juice Sucrose		Glucose		Purity	
	F	M	canes		juice		F	M	F	M	F	M	F	M	F	M
13	14	146	121	135	97	89	63	65	18.03	18.53	15.54	16.11	0.61	0.48	86.18	86.95
16	15	149	165	113	124	74	77	62	18.58	18.70	15.84	16.08	0.51	0.44	86.27	86.17
17	18	151	135	152	124	99.5	81	65.6	17.97	17.49	15.23	14.78	0.58	0.53	84.74	84.48
20	19	141	121	125	121	80.5	81	66.5	18.41	18.70	15.95	16.17	0.42	0.45	86.49	86.64
21	22	130	133	123	136	88	87.5	64.3	18.44	17.67	15.97	15.01	0.37	0.50	86.57	84.91
24	23	110	180	123	164	79	103	62.8	17.94	17.43	15.40	14.63	0.47	0.51	85.84	83.92
25	26	114	117	135	133	90	85	63.9	17.63	18.27	15.15	15.89	0.47	0.38	85.98	86.95
28	27	141	113	141	136	91	86	64.5	18.37	17.71	15.95	15.12	0.42	0.52	86.84	85.49
29	30	120	107	136	113	88	71	62.8	18.61	18.31	15.60	16.13	0.40	0.49	86.68	85.17
32	31	140	92	165	116	106	76	65.5	18.04	17.80	15.35	15.17	0.47	0.47	85.06	85.24

The yield of stripped cane in maunds was as follows :—

TABLE II
Weight in maunds of stripped cane Co. 213

Plot		Mosaic-free	Mosaic infected
F	M		
13	14	20.36	13.17
16	15	16.99	11.83
17	18	18.46	16.68
20	19	18.72	13.79
21	22	18.89	21.00
24	23	20.20	22.61
25	26	21.00	20.35
28	27	17.69	18.19
29	30	19.27	19.20
32	31	21.31	17.93
Mean		19.489	17.475

Difference 2.014 maunds or 10 per cent. is significant.

The statistical significance of the differences in yield shown above and of the other differences as shown by the analysis of the randomised samples, was calculated by Student's method and gave the following results :—

TABLE III

Co. 213.	Mean differences (mosaic-free minus mosaic)	Standard deviation	Mean difference	Odds
			Standard deviation	
Weight of cane . . .	2.014	2.89	.7	30:1
Percentage juice to cane	1.4	1.27	1.1	216:1
Calculated juice per plot	7.45	15.8	.47	11:1
Brix . . . . .	.14	0.47	.3	4:1
Sucrose . . . . .	.2	.6	.3	4:1
Glucose . . . . .	.005	.07	.07	..
Purity . . . . .	.5	.99	.5	11:1

The difference in weight of cane, and juice to cane were statistically significant. The quality of the juice as measured by brix, sucrose, glucose and purity was not affected.

A tonnage experiment on Co. 213 was again carried out by the Plant Pathologist, U. P., at the Cawnpore Research Farm. The decrease in yield of mosaic infected cane was, however, not sufficiently great this year to be statistically significant.

PROPERTIES OF MOSAIC VIRUS

Distribution throughout cane.—Setts from various positions on 100 mosaic canes of Co. 213 were compared for germination and mosaic development.

TABLE IV

Position	%germination	%mosaic shoots
1 (top)	45	45
2	25	33
3	17	24
4	13	30
5 (base)	8	42

The germination of the basal sett is seen to be low, and there is a strong suggestion that the mosaic percentage is lowest in the middle portions, though more experiments are required to make the latter point definite.

Treatment of setts.—Setts from mosaic clumps subjected to various steeping treatments gave the following results:—

TABLE V

Treatment	%germination	%mosaic shoots
Bordeaux mixture (4 : 4 : 50), 2½ hours	50	28
1% "Clensel oil", 1½ hours	31	35
Hot water (55°-60°C), 1 hour	36	22
Water (unheated), 24 hours	34	8
Lime solution (saturated), 2½ hours	0	..
No treatment	40	11

Soaking in water thus appears to have little effect, whereas treatment with heat and certain chemicals increases the disease.

Artificial transmission.—Inoculation experiment during the present season have been marked by the consistently low percentage of successful infections. A comparison with the weather records and dates of inoculation in previous years failed to show any correlation of this poor transmission with humidity or temperature. A more probable cause is an increased resistance of the varieties used—Co. 213, and to a lesser extent Co. 210—both of which have been consistently rogued at Pusa. In support of this suggestion the following figures are of interest; they show the decrease in mosaic percentage in the tonnage plot rows planted with setts from mosaic plants only:

1931	1932	1933	1934
57—71 per cent	52—75 per cent	40—56 per cent	31—45 per cent.

Other varieties of cane, and Co. 213 and 210 from other areas will therefore be tried as test plants. In the meantime, it has been demonstrated that maize can be used as a test plant for sugarcane

mosaic juice, giving consistent 50-80 per cent infection, and providing a longer working season. Results obtained in this way will of course require confirmation on sugarcane.

Inoculation experiments with (1) mosaic leaf juice passed through L₃ Chamberland filter, (2) healthy juice+(1), and (3) unfiltered mosaic juice, produced mosaic symptoms from (3) only, the percentage infections being 10 per cent. for Co. 213 and 50 per cent. for maize.

Mosaic leaf juice heated to 50°, 60°, and 70°C for 10 minutes gave no infection on Co. 213, the unheated juice giving 20 per cent. infection. Further experiments were made, using maize, with heat treatment at lower temperatures; 45°C gave no infection, whilst 40°C gave 60 per cent. mosaic. The thermal death point therefore lies between 40° and 45°C, in which it resembles that of tomato spotted wilt, and of crinkle and mild mosaic of potato.

Inter-varietal transmission—Mosaic leaf juices of five varieties were inoculated into each of ten varieties, and where mosaic was produced, a water-colour record was made of the pattern produced. The result of 10 inoculations on each variety are shown in the table.

TABLE VI

	Co. 213	Red Mauritius	M 16	Co. 313	Saretha.
Co. 213 . . .	4 plants	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	3 plants
Co. 210 . . .	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>
Co. 313 . . .	2 plants	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	2 plants
Co. 416 . . .	7 plants	3 plants	1 plant	1 plant	2 plants
Co. 419 . . .	1 plant	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>
Co. 420 . . .	6 plants	<i>Nil</i>	<i>Nil</i>	1 plant	1 plant
B 3412 . . .	8 plants	3 plants	4 plants.	4 plants	4 plants
Lalgira* . . .	4 plants	1 plant	<i>Nil</i>	3 plants	1 plant
Saretha . . .	4 plants	<i>Nil</i>	5 plants	6 plants	1 plant
P. O. J. 2878 . .	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>

* This variety has not previously been observed to show mosaic.

Nature of virus.—The work recorded in previous years on the association of mosaic virus with an organism having a visible cyclostage has been written up for publication.

Attempts to secure fresh isolations of this organism in 1935 have not so far met with success. It is possible that they were started too late in this season.

III. BACTERIAL AND FUNGAL DISEASES OF SUGARCANE.

STINKING ROT

This disease was first recorded in last year's report, and was shown to be caused by an organism of the *Bacterium pyocyaneum*

type. Further work has shown that two organisms are present, one giving whitish, and the other bluish colonies on nutrient agar. Inoculation experiments demonstrated that the bluish strain was pathogenic, the whitish strain being saprophytic, but that a mixed culture was the most effective in bringing about the disease artificially. Needle inoculation was not very successful. Removal of a plug of tissue and introduction of the culture, followed by replacement of the plug, gave a fair percentage of successful inoculations. Introduction of the culture through borer holes, however, gave uniformly successful results, and it is believed that this is the usual method of natural infection.

A fuller description of this disease has been written up in the form of a paper, which has been submitted for publication.

ASSOCIATION OF MICRO-ORGANISMS WITH BORER ATTACK

Early in 1935 complaints were received of the prevalence of so-called "red-rot" in parts of Bihar. If the apparently healthy canes as received at the mills were split open longitudinally, a varying percentage showed reddening of the inner tissues. The discoloration was usually localised, but sometimes spread throughout the entire length. It was demonstrated by Mr. Noel Deerr that the sugar content of such canes was frequently reduced to one half or one third of that of the healthy canes.

Visits to the affected areas showed that this type of red discoloration had no connection with the true "red-rot" disease caused by *Colletotrichum*. It was observed that affected cane was always attacked by borers, and that the reddened areas were localised at, or spreading from, the holes made by borer; borer holes unaccompanied by internal reddening were rare.

Examination in the laboratory showed that in nearly all cases of discoloration micro-organisms were present, but that these were all common saprophytic mould fungi, yeasts, and bacteria such as one would expect to find on a sugary substratum freely exposed to air infection. Many fungi give a red coloration on sugar media, and it is probable that the reddening of bored cane is largely, though not entirely, due to such fungi. No parasitic fungi were associated with this type of reddening, which is moreover, different in appearance from the discolorations produced by *Colletotrichum falcatum* and *Cephalosporium sacchari*.

It is clear, therefore, that the primary trouble is the prevalence of borer, and that the fungal and bacterial infection is purely secondary. That this type of discoloration has not been brought to notice before is attributable to the facts that apparently healthy cane has not been examined in this way in previous years, and that borer attack has been less widespread.

Local Survey.—A survey was made of the material arriving at nine mills scattered throughout North Bihar, and the data collected

confirmed the above conclusions. Of canes taken at random, the number of discoloured canes ranged from 30 per cent. to 78 per cent, and of these unsound canes the percentage of the reddened portion ranged from 12 per cent. to 31 per cent. The sugar content was reduced to one half or one third in the immediate neighbourhood of the borer holes, but the remainder of the cane showed a slighter loss.

Cause of reduced sugar content.—It was considered that the lower sugar content of bored and reddened canes might well be due to utilisation of sugar by the infecting micro-organisms. In this case one would expect the loss to increase rapidly with time.

Experiments were therefore carried out to determine the effect of storage on the sugar content of bored cane. Healthy and bored canes were stored at a temperature ranging from 47°F to 75°F for 10 days, 100 canes being taken each day for examination.

It was found that although the percentage discoloration of the bored canes increased steadily from 30 per cent to 58·5 per cent there was no notable loss or inversion of sugar by fermentation during this time. Neither sound nor unsound cane showed any appreciable change in weight, extraction, Brix, or sucrose, though there was a slight increase in glucose in the bored canes during storage. Microbiological action is therefore slight, and moderate storage is no more objectionable for bored than for sound cane.

Bacterial and yeast counts of the pressed juice were surprisingly high, and were at first greater for the bored cane. It was found, however, that the greater proportion of these organisms, which were shown to be capable of inversion and fermentation of sucrose, came from the surface tissues and the immediate neighbourhood of the borer holes.

The above experiments indicate that loss of sugar due to micro-organisms is very localised and that the reduced sugar content of bored cane is principally due, not to loss of sugar, but to interference with the metabolism of the plant which prevents the normal production of sugar.

SMUT (*Ustilago scitaminea* Syd.)

In addition to varieties recorded in the last report the following were found to show smut infection at Karnal Sugarcane Substation :

Co. 205, 346, 349, 368, 380, 381, and 391. The fungus was isolated from Co. 205, 213, 290, 368, and 391, and was found to grow well on potato-dextrose agar, Richard's agar, and Dox's agar. In artificial cultures chlamydospores are rare, but secondary sporidia are freely formed. So far little morphological difference can be detected among the various strains.

Smut infection of P. O. J. 2878, Co. 416 and Co. 419 was successfully obtained by infecting the buds of setts with smut

spores or sporidia ; in one case infection took place through the cut ends.

RED ROT (*Colletotrichum falcatum* WENT.)

Five strains of this fungus are under study isolated from thick cane at Coimbatore, Deshi thick cane at Patna, thin cane at Sepaya, and from Co. 210 and 213 at Pusa. The fungus grows well on Richard's agar, about only the Coimbatore and Sepaya strains have produced spores freely.

SEEDLING DISEASES

Helminthosporium.—Seedling disease was again examined at Coimbatore. The principal causal organism, tentatively regarded as *Helminthosporium sacchari* in last year's report, has now been indentified as *Helminthosporium halodes* Drech. Isolations from sugarcane—which is a new host recorded for this fungus—have been successfully inoculated into wheat, barley, maize and jowar.

Seed and soil treatments with an organic mercury fungicide has given successful control ; a 0.25 per cent. solution of Uspulun was used, but the manufacture of this product seems to have been discontinued in favour of the mercurial dusts. Treatment in the seedling pans was found sufficient at Coimbatore, the transplanted seedlings remaining healthy in the field.

Seed brought to Pusa for germination also developed the disease, but it cannot yet be stated with certainty that the disease is seed-borne

A more weakly parasitic strain of *Helminthosporium* isolated from diseased seedlings has been identified as *H. tetramera* Mackinney.

Pythium spp.—A species of *Pythium* isolated from diseased seedlings from Coimbatore early in 1935 appears to agree morphologically with *P. graminicolum* Subr. and can infect maize and jowar seedlings. Another strain of *Pythium* from seedlings growing at Pusa belongs to the *Nematosporangium* group, and has so far failed to form oospores in culture. A *Pythium* of the *Sphaerosporangium* group was isolated from stems of Co. 210, and differs in its morphological characters from all recorded species.

Experiments on culture media of pH from 3.5 to 9.5 indicate that the optimum pH for growth is 5.5 for *Colletotrichum* and *Thielaviopsis*.

IV. PROGRAMME FOR 1935-36

The programme for the coming year is subject to modification, but the following are among the lines of research anticipated :

1. Continuation of tonnage experiment, if possible with thick canes.

2. The purification and transmission of sugarcane mosaic virus, and its physical properties.

3. Fungi—

(a) Physiological studies of different strains of *Colletotrichum falcatum*.

(b) Varietal resistance to Smut.

(c) Studies on *Pythium* spp.

(d) Survey of cane crop for disease.

V. PUBLICATIONS

Abstracts of the first three papers below, and also a paper by Mr. S. A. Rafay on "Recovery of chlorophyll in certain varieties of mosaic-infected canes," were read at the Indian Science Congress, held at Calcutta in January 1935.

Desai, S. V. . . . Stinking Rot of Sugarcane, Ind. J Agric. Sci. 1935 5 : 387-392.

Do. . . . Organisms associated with sugarcane mosaic and their relation to mosaic virus. Ind. J. Agric. Sci. 1935, 5 : 367-386.

Rafay, S. A. . . . Physical Properties of Sugarcane mosaic virus. Ind. J. Agric. Sci. 1935, 5 : 663-70.

Subramaniam, L. S. . . . Common Diseases of Sugarcane and methods for their control. (Bulletin in course of Publication).

● REPORT OF THE IMPERIAL ENTOMOLOGIST

[HEM SINGH PRUTHI, M.Sc., PH. D. (CANTAB.)]

I. ADMINISTRATION

Mr. P. V. Isaac, Officiating Imperial Entomologist, remained in charge of the Entomological Section up to 4th September 1934. Dr. H. S. Pruthi joined as Imperial Entomologist in the forenoon of the 5th September 1934, and remained in charge of the Section for the rest of the year under report.

Mr. P. V. Isaac, Second Entomologist (Dipterist), proceeded on leave on average pay for eight months combined with leave on half average pay for two months with effect from 2nd January 1935, in continuation of the Christmas holidays.

Rai Bahadur C. S. Misra, Assistant Entomologist, was on leave on average pay for four weeks with effect from 25th November 1934. He again went on leave on average pay for three months and twenty-five days with effect from 21st March 1935 preparatory to retirement.

II. TRAINING

Mr. Hira Nand Batra, post-graduate student from the N. W. F. Province, completed his course and left Pusa on 31st October 1934.

Mr. F. J. Vevai, post-graduate student was under training throughout the year. In addition to the work on general economic entomology he was carrying out a special investigation on the morphology and bionomics of the sugarcane root borer *Emmalocera depressella*.

Mr. K. V. Rao was admitted as a post-graduate student on 1st November 1934.

Mr. Ram Mohan Rao, a post-graduate student of the Benares Hindu University worked on Coccidae in the Section for about a week during January 1935.

The Dairy students were given a series of lectures and demonstrations on insects of veterinary importance.

Dr. J. K. Dubey, Agricultural Officer of Bhopal State spent some time in this Section familiarising himself with important insect pests of crops.

III. SPECIAL INVESTIGATIONS

For a fairly long time in the year under report the Imperial Entomologist was the only gazetted officer on duty. He had therefore to spend great deal of time in the training of students and

in attending to all kinds of routine work of the section. Furthermore, as explained hereafter, considerable amount of time had to be devoted to the proper storing, preservation and re-arrangement of the valuable Insect collections and scientific records of the section which had got badly damaged and mixed due to the earthquake of 1934. The collections required immediate attention of the whole staff to save them from further damage by moulds, pests, etc. It will thus be seen that only limited amount of time could be devoted to research work. Special investigations on the following problems were carried out :—

Pests of Sugarcane.—For the last several years Rai Bahadur C. S. Misra, Assistant Entomologist, had been taking observations on the more serious pests of sugarcane but in February 1935 the Imperial Entomologist himself took over this work in view of the impending retirement of the Assistant Entomologist.

At the time of the harvest of 1934-35 crop in February about eleven thousand canes were carefully examined to determine the comparative incidence of various pests. The results are tabulated below :—

Name of field	Variety of cane	Healthy Per cent.	Top-borer Per cent.	Stem-borers Per cent.	Root-borer Per cent.	Termites Per cent.
Gonhri .	Co. 331 .	22.36	55.37	15.40	45.22	1.08
Pangarbi	Co. 214 .	5.75	82.11	60.95	43.11	9.59

As usual numerous canes were infested by more than one pest, the most common combination in the case of Gonhri field being top+root borer and in Pangarbi field top+stem+root borer and top+stem borers.

Thus the top-shoot borer (*Scirpophaga nivella*) proved to be the most serious pest. The root borer (*Emmalocera depressella*) also attacked a fairly large percentage of canes, but the economic loss due to its infestation was proportionately very small. Among the stem borers *Argyria sticticraspis* predominated, *D. venosata* and *Chilo zonellus* being in very small number.

For the foregoing readings canes were examined in lots of eight replications, each replication covering the same amount of area for each of the two varieties examined. The data are being worked out statistically and the result will be published in due course.

In view of the variable results which have been obtained so far at Pusa and elsewhere in India about the incidence of various pests on different varieties of cane, a randomized plot was laid out in February 1936 in Harpur Jhilli and planted with five varieties of cane, namely, Co. 210, Co. 213, Co. 299, Co. 313 and Co. 331, over an area of about four acres. A part of this area was planted with

setts previously treated with lead arsenate, copper sulphate, formaline and creosote. Detailed monthly readings of the seasonal history and incidence of various pests on different varieties both in treated and untreated plots are being taken. About four thousand canes of each variety are examined every month. The progress of the development of various borers as shown by the appearance of "dead hearts", on all varieties taken together, up to the end of June is tabulated below :

Months	Total no. of dead hearts.	Dead hearts caused by stem-borers.	Dead hearts caused by top-borer.	Dead hearts caused by root-borer.
	Per cent.	Per cent.	Per cent.	Per cent.
April	5.42	0.33	0.21	4.88
May	5.49	1.79	0.34	3.35
June	9.38	4.36	2.31	2.71

It may be mentioned that all "dead hearts" caused by borers in the area in which the foregoing readings were taken were removed at the time of observation, therefore the figures given against each month are of the dead hearts which appeared during the month.

To compare the incidence of borers in February plantings with that in October plantings and ratoon crop one thousand canes of each of the two latter crops have also been examined during the last three months. The results are given in the following table :—

A statement of percentage of "dead hearts" in ratoon-crop, October and February plantings.

Month	February (1935) plantings.	October (1934) Plantings.	Ratoon crop.
April	4.30	10.8	..
May	7.5	11.0	9.4
June	17.45	26.0	24.90

It will be noticed that the incidence of borers in the October and ratoon crops even when grown in one of the best fields at Pusa, has been throughout much higher than in the February plantings. It appears that such crops in addition to getting heavily infested themselves act as source of infestation for February plantings, as they afford food to borers during the period between the harvest of old and the sprouting of the next crop. It will also be observed that there was very big increase in the number of dead hearts in all the three crops after May.

The egg-masses and adults of *Pyrilla* spp. were observed in small number up to the end of May, but practically no nymphs were seen up to that date, which indicates that the breeding of this pest was at a very low ebb during this period. This was obviously due to excessive dry heat, as in June, after a few showers, the pest started breeding both in the field and the laboratory.

In addition to the pests described above the following were found doing damage in the cane fields :—

The cane hispa *Asamangulia cuspidata* Maulik has been rather serious in all fields at Pusa since April. *Brumus suturalis* and *Mylocerus blandus* have also been met with in fair number. *Calocoris angustatus* F., *Monolepta signata*, *Formicomus* sp. and *Mylocerus 11-pustulatus* have also been found.

The sucking insects *Aleurolobus barodensis*, *Lepidosaphes* sp. and cane thrips *Anaphothrips citricinctus* Karny have also been fairly common. The morphology and bionomics of *Lepidosaphes*, a probable causative agent of the "yellowing disease", has been investigated and a paper on the subject is under preparation for publication.

Trionymus sacchari increased abnormally in August 1934. *Assamia moesta* and *Aphis sacchari* were also common in August last year.

Parasites of various cane pests :—The eggs, nymphs and adults of *Pyrilla* spp. were found to be parasitized last year by the same parasites as in the previous years and the parasitism as usual was very high during July-December. This year up to the end of June the parasitism has remained low which is also usual.

The following parasites of other cane pests are recorded for the first time :—

The eggs of the root borer (*Emmalocera depressella*) have been found to be parasitised by the chalcid wasp *Trichogramma minutum* (Pl. IV fig. 1) almost throughout the year. This season parasitism remained 3-4 per cent. up to the end of May but during June it went up to 40 per cent. Each host egg generally contains three parasites. The parasite takes about 7 days to complete its life cycle in the laboratory in summer months. This parasite will be carefully studied during the rest of the cane season as it seems to have potentialities of proving useful if properly developed.

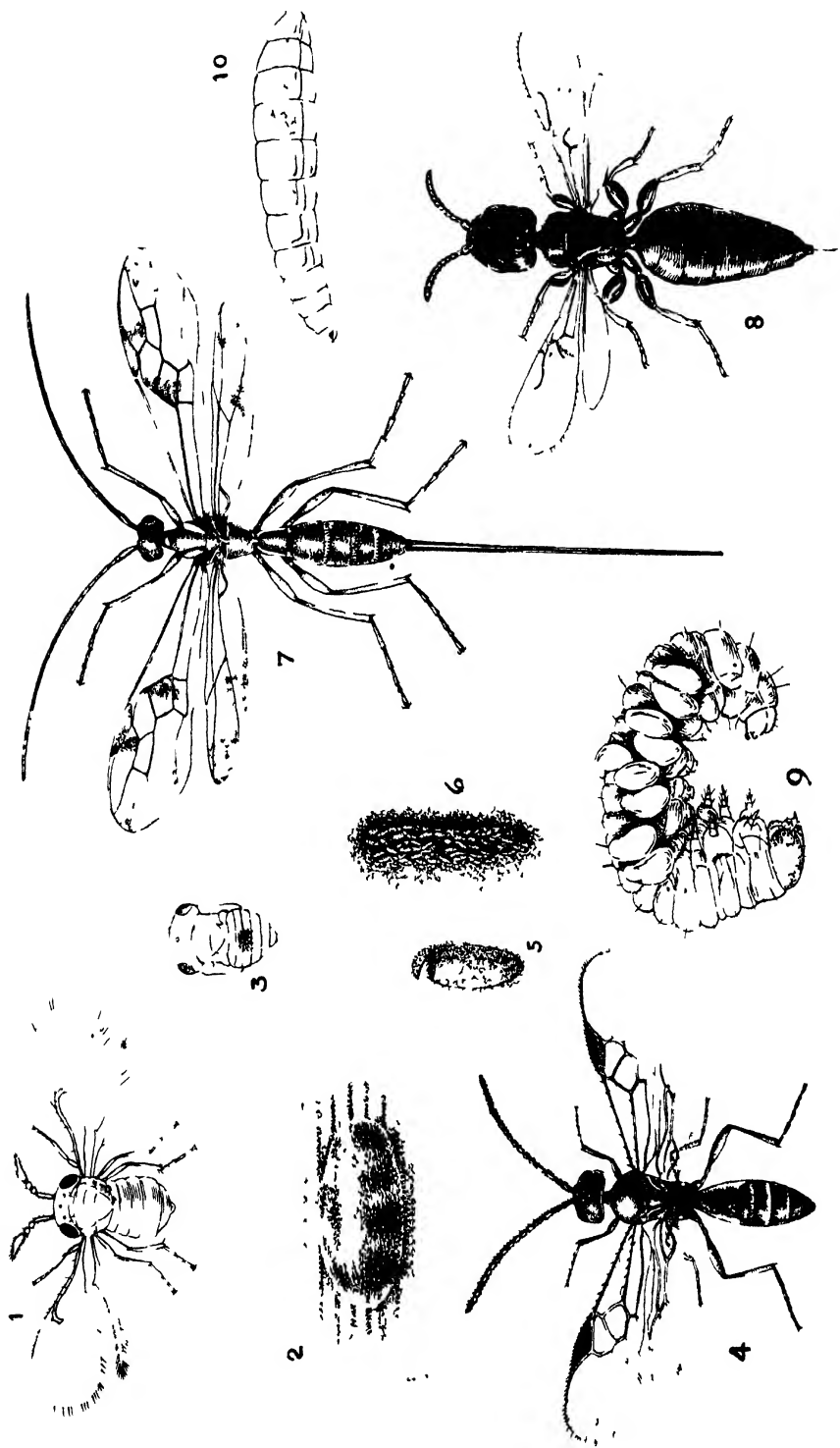
The larvae of *Emmalocera depressella* have been found to be parasitized by a braconid *Glyptomorpha deesae* and a bethylid wasp (Pl. IV figs. 7 and 8). The braconid is a powerful parasite but parasitism has remained 3-4 per cent. up to the end of June. The bethylid parasite appears in appreciable number (10 per cent.) in winter only when the root borers are full-grown and have already done damage to the canes. This parasite does not therefore seem to be of much practical importance.

The stem-borer *Argyria sticticraspis* has been found to be parasitized by *Apanteles flavipes* (Pl. IV fig. 4) late in the season. Last winter it was very common in all cane fields, actively moving about on leaves and stems in search of the holes of the borers through which it enters and parasitizes the borers inside. The number of parasites obtained from each borer varies from 40 to 80.

EXPLANATION OF PLATE IV.

- Fig. 1. A Chalcid parasite (*Trichogramma minutum*.) of the eggs of *Emmalocera depressella* ($\times 72$).
- „ 2. The parasitized egg, highly magnified.
- „ 3. Pupa of the parasite, dorsal view ($\times 72$).
- „ 4. *Apanteles flavipes*, parasite of the stem borer *Argyria sticticarpa* ($\times 25$).
- „ 5. A cocoon of the same ($\times 9$).
- „ 6. A cocoon mass of the same ($\times 2$).
- „ 7. *Glyptomorpha deesae* Cam., female ($\times 5$), a parasite of the borer *Emmalocera depressella*.
- „ 8. A Bethyloid parasite of the borer *Emmalocera depressella* ($\times 11$).
- „ 9. The parasitized borer *Emmalocera*; note the parasitic larvae on the host.
- „ 10. Larva of the Bethyloid parasite; magnified.

PLATE IV.



The morphology and bionomics of this parasite is also being studied in detail, as it might have potentialities of proving useful in the control of the stem-borer.

Insect vectors of "Leaf-curl" of Tobacco.—The leaf-curl disease of tobacco is on the increase at Pusa and other places in North India. It is believed to be a virus disease. Last autumn, in the Botanical area at Pusa the disease was noticed about three weeks after the crop had been transplanted. In the middle of November about 50 per cent. of the plants were reported by the Botanical section to be affected by this disease. In the end of December over 70 per cent. of the crop was found to be badly affected. In addition to leaves, the stems of many diseased plants were twisted and bent and the whole plants were stunted in growth. The amount of economic loss caused by the disease can therefore be easily imagined.

The Second Economic Botanist distinguished 4 or 5 types of the disease in his area last year and the diseased plants required for entomological investigations were kindly supplied by him. Moreover, the Imperial Economic Botanist placed at the disposal of the Imperial Entomologist a plot of tobacco for experiments and allowed his staff to make daily collections of and take observations on the Insect fauna in all his tobacco plots covering an area of about two acres. The valuable assistance thus rendered by the Botanical section is gratefully acknowledged.

In order to discover the probable insect vector or vectors of the disease a complete collection of the Insect fauna of both healthy and diseased tobacco was made at Pusa and in the neighbouring villages from the beginning of October up to the end of March when all plants of the crop were in flower and the vegetative growth was at an end. The collection was made from 6 A.M. to 10 P.M. and includes about 400 species of different insects, of which, of course, a considerable number appear to be only casual visitors of tobacco. Virus diseases as a rule are known to be transmitted by sucking insects only. Of such insects about 10 species were commonly met with on tobacco, but only two species, namely a Capsid bug *Engyptatus tenius* and an Aphid, especially the former, were present on tobacco in large number throughout the season. In view of the limited amount of staff available for this work only one species, viz., *Engyptatus tenius* was selected for transmission experiments. For the same reason only the two common types of disease, designated as A and B, were selected for study.

Young and adult specimens of *Engyptatus tenius* collected from the field were fed on diseased leaves enclosed in cellophane tubes for varying amount of time (12 hrs. to 5 days) and then introduced on healthy plants grown in pots and in the field and covered with wire-gauze cages and muslin bags since their germination. In this way about 75 plants were treated with A type and 50 plants with B type during December and January. In April when all bags

were removed, about a dozen plants, mostly those treated with B type, showed an abnormal growth, but none exhibited the complete symptoms of the disease.

The bug cannot yet be declared "non-guilty", as the work was handicapped by the following drawbacks:—

- (a) The work was started in the beginning of October (about a month after the Imperial Entomologist joined at Pusa) when the crop was already in the field and no stock of bugs bred pure was available. In the absence of such a stock stray specimens collected from field had to be used for feeding and transmission experiments.
- (b) The properties of the virus concerned and the various stages in the development of the disease are yet not known. It is possible that the atypical growth mentioned above is an early stage in the development of the disease and that the next stage is caused by some other insect.

It is therefore proposed to continue the work on this bug and other suspected insects, especially the Aphid, next season if the scheme of work proposed to the Imperial Council of Agricultural Research gets sanctioned in time. In the meantime, the life-history and alternative food plants of *Engyptatus tenius* and the Aphid are being studied and efforts are being made to breed pure stocks of these insects for transmission experiments next winter.

A New pest of Linseed at Pusa.—For the last few years a minute Cecidomyid fly has been observed to be doing damage to linseed flowers in the Botanical area at Pusa. In 1933 the damage by this pest was about 50 per cent. In February 1935 a special investigation of the bionomics and economic status of the fly was undertaken. This year the maximum number of affected flowers has been about 15 per cent. A series of specimens of the fly was sent to a specialist for identification and it has been declared to be a new species of *Dasyneura* and named as *D. lini* Barnes. The flies which are of beautiful orange colour are fond of sunshine and are most active during the brightest part of the day (11 A.M. to 3 P.M.). At this time they hover from plant to plant, laying eggs on the outside but often inside the flower buds. Young larvae hatched from the eggs laid on the outside also work their way in the buds. The larvae live on the stamens and other internal organs of the unopened flowers, which consequently present an emaciated appearance and in most cases do not open at all. The infested flower-buds can be easily recognized in the field by the crumpled appearance of the exposed portion of the corolla. It was found that the imported varieties of linseed (Australian) were more heavily attacked than the indigenous ones. Perhaps this differential susceptibility is connected with the different times of flowering. This point will be carefully investigated next year.

The larvae when full grown (on an average 7 days after hatching) come out of the buds, drop in the soil and pupate. The pupation period lasted 4-7 days in the laboratory in which the temperature varied from 70°F. to 82°F.

In view of the proposed extension of linseed cultivation in India it is feared that this pest is likely to become of major importance in future.

Pests of Stored grains.—The common grain weevil, *Calandra oryzae* exhibits great variations in its bionomics and life-history in various parts of the world, presumably due to varying conditions of climate. A detailed study of the influence of different temperatures and humidities on this weevil has been undertaken. The common dessicators were improvised as the humidity jars and special stands to take about a dozen rearing tubes which can be rapidly put in and taken out of the jars, were devised and got locally made at a low cost. The complete apparatus is working very satisfactorily. It took some time to devise and fit up the apparatus, the observations on the biology of the weevil therefore have yet been taken for a short time only. It appears that the weevil if kept at humidity below 60 per cent does not lay eggs and even if a few eggs are laid, they do not hatch at all.

Alongside the biological investigations mentioned above a study of the repellant action of some cheap country materials on the weevils was started last autumn. The weevils under experiment have not yet passed through any monsoon season during which they are known to propagate most, the final readings therefore will be taken in October or November and results reported in due course.

Pests of Fruits and fruit trees.—The important pests of fruit at Quetta and the neighbouring districts have been under observation during the summers of 1932, 1933 and 1934. Several notorious pests prevalent in other countries, e.g., the Codling moth, San Jose Scale, etc., have been found to occur in this area. A brief account of these pests was given in the reports of the years named above, but a comprehensive paper on the subject has been under preparation during the year under report. Similarly a paper giving a brief account of the common fruit pests of N. W. F. Province has been prepared.

Jassidae (Rhynchotha).—In view of the importance of Jassidae as pests of various crops and transmitters of some virus diseases, a collection of the species of this family occurring at Pusa has been made since the spring of this year. The collection has already yielded several novelties. A paper describing these novelties together with those from other parts of India has been prepared and will be shortly submitted for publication.

Life histories of Indian Insects.—The study of the life-histories and habits of insects doing damage to economic or wild plants was

continued. The immature stages of those which proved to be of special interest were figured and illustrated. Altogether about 80 insect species have been studied during the year under report, of which the following are of special interest:—Larvae of *Tischeria ptarmica* mining leaves of *Zizyphus jujuba* reared up to the adult stage for the first time; caterpillars of *Mabira eryxalis* Wlk., *Cnaphalocrocis medinalis* Guen. and *Mocis frugalis* Fab. found feeding on leaves of paddy. The bionomics of two Braconid parasites of the larvae of *Sphenarches caffer* and the vine leaf caterpillar *Sylepta lunalis* have been worked out.

The life-history of a species of *Tabanus* has been studied in detail. It is an active blood sucker of cattle. The eggs are laid in packets of about 850 each on the leaves of *Rumex nepalensis* growing near water. There is only one brood in the year.

To determine the number of broods in a year of the common *Metacanthus pulchellus* Dallas, rearing on a large scale of the bug was undertaken last spring. From the beginning of February up to the end of June the bug completed six generations.

IV. OBSERVATIONS ON OTHER INSECT PESTS.

The following important pests of various crops occurred again in Pusa:—*Sylepta lunalis* Guen. was bad on grape vines during July. It was successfully controlled by spraying with lead arsenate. *Dichocrocis punctiferalis* Guen. was found in numbers in guava fruits and castor capsules. Aphids appeared on various cultivated crops. In some cases they were kept in check to a certain extent by the presence of *Chilomenes sexmaculatus* and other Coccinellid beetles, in other cases they were successfully controlled by spraying with nicotine sulphate. The coccinellid beetles were found to be parasitized by numerous Chalcid parasites. *Agrotis* spp. appeared on tobacco, potato, gram, carrot, beet and turnip plants. They were controlled by hand-picking and baiting. *Euzophera perticella* Rag. was found breeding on brinjal stems. *Leucinodes orbonalis* Guen. was found boring brinjal shoots and fruits. *Pemphres affinis* Fsh. was present in numbers in the stems of old American cotton, the Aligarh white and the Punjab F. 49 cotton in September 1934. *Idiocerus* spp. were present in numbers on young mango plants, mango leaves and flowers. Spraying with rosin compound, when the plants were not in flower, was found effective against them. *Nupsierha bicolor* Thoms. occurred on soybeans in July. *Pulvinaria psidii* Mask. was bad on young grafted mango plants. It was successfully controlled by spraying with rosin compound. *Dysdercus cingulatus* Fb. was found in large numbers on cotton and bhindi throughout the season. *Plutella maculipennis* Curt. was common on cabbage and cauliflower from November to March. *Arytaina (Psylla) isitii* Buckt. occurred on indigo leaves. *Euchrysops cnejus* Fb. damaged flowers and pods of *cajanus indicus* and mung. *Aulacophora abdominalis* Fb. was

bad on cucurbit plants. *Exelastis atomosa* Wlsm. was found boring into the pods and eating the seeds of *cajanus indicus* during April. *Papilio demoleus* Linn. damaged citrus leaves. *Earias fabla* Stoll. was found boring the pods and young shoots of *bhindi*. *Laphygma exigua* Hb. infested lucerne leaves. *Monophlebus* sp. was noticed to be present on mango, *mahua*, *sisir* and jack trees. Tur-pod fly was found in pods of *cajanus indicus*. Fruit flies were found attacking various cucurbit and other fruits, such as *Karaela*, *phoont*, cucumber, melons, *aegle marmilos*, sapota, peach, etc. *Sesamia* sp. was observed boring into the maize stem and causing 'dead hearts'. *Margaronia indica* Saund. infested leaves of melons and some other cucurbit plants. *Trabala vishnu* Lef. on leaves of *Quisqualis indica*.

The damage by the following major pests of crops was not appreciable during this year at Pusa :—*Diacrisia obliqua* Wlk., *Maruca testulalis* Geyer, *Heliothis obsoleta* Fb., *Utetheisa pulchella* Linn., *Cirphis unipuncta* Haw., *Spodoptera mauritia* Bisd., *Achaea janata* Linn., *Pieris brassicae* Linn., *Etiella zinckenella* Tr., *Nephotettix bipunctatus* Fb., *Nephotettix apicalis* Mots., *Nodostoma subcostatum* Jac.

The occurrence of the following insects in Pusa on the hosts indicated is noteworthy :—*Prodenia litura* Fb. on berseem leaves; *Engytatus tenius* on leaves of bottle gourd; *Virachola isocrates* Fb. larvae boring into the fruits of *litchis*; some Gracillariad caterpillars mining the leaves of *Bassia latifolia* (May 1935); *Mabra eryxalis* Wlk. on leaves of paddy. *Chauliops* sp. was found in numbers on soy-bean during July. *Tischeria ptarmica* Meyr. was reared in Pusa for the first time in 1934 from larvae mining leaves of *Zizyphus jujuba*.

V. INSECT SURVEY AND COLLECTIONS.

Due to frequent shiftings consequent on the earthquake of last year and subsequent unsatisfactory condition of storage for want of space, the valuable insect collections of the Section got badly mixed and damaged. In October when more space became available, the poisoning of the collections and weeding out of pins and damaged specimens was started. This work together with the re-arrangement of the mixed collections took about four months. Then the proper registration (for which special registers were got printed) and card cataloguing of the collections was undertaken. This is a very formidable work indeed. About one thousand species, comprising about 20,000 specimens have been catalogued so far and it will take about a couple of years to make the registers and card catalogues up to-date. The registration of the collections is very essential so that we may have a complete record of what we possess. The utility of the card catalogue need hardly be emphasized. When completed it will be a very useful source of reference for the food plants, seasonal and regional distribution of the Insect fauna of India. It is proposed to publish a series of bulletins on

this subject so that the data may be readily available to the Provincial entomologists and other workers for use in connection with their economic or systematic work.

A large number of insects occurring at Pusa were collected to fill up the lacunae in the collections, which were furthermore enriched by the addition of about one hundred named species, some of which were received from Government Entomologists of the Punjab, Madras and Mysore by exchange or presentation.

The following lots of specimens were received back after naming and were incorporated in the collections. The assistance rendered by various specialists in this connection is gratefully acknowledged :—

- (a) Coccidae of Baluchistan; from Mr. F. Laing, British Museum, Natural History, London.
- (b) Aleyrodidae (white flies); from Mr. K. S. Lamba, Lecturer in Zoology, Science College, Nagpur.
- (c) Cecidomyiidae on linseed, Pusa; from Dr. H. F. Barnes, Rothamsted Experimental Station, Harpenden.
- (d) Fruit Pests of N. W. F. P., including slides of Aphidae; from the Imperial Institute of Entomology, London.
- (e) Microlepidoptera; from Mr. T. Bainbrigg Fletcher, Gloucestershire, England.
- (f) Ephemeroptera including three new species; from Indian Museum, Calcutta.

Several lots of unnamed specimens of Mites, Aphidae, Termites, etc., were sent to the Imperial Institute of Entomology, London, for favour of identification.

VI. ADVISORY AND MISCELLANEOUS.

Insect Pests: Fifty-nine parcels of insect specimens (comprising about 200 species), received from various parts of India during the year were examined and identified as far as possible. In the case of pests suitable control measures were suggested.

Information regarding the control of Termites and some important pests of sugarcane, stored grains, and other crops was supplied to over thirty different enquirers.

Advice regarding the preparation and use of insecticides, and about the preservation of insect specimens was given to five different correspondents.

Samples of leather treated with camphor oil, received from Messrs. Garnar & Sons, London, and about twenty samples of wood treated with a proprietary chemical by the Imperial Chemical Industries, Limited, were tested against the attack of termites.

Information about the parasites and predators in India of the Australian sheep Blow fly and the Buffalo-fly was supplied to the

Council of Science and Industrial Research, East Melbourne, Australia.

The potato and other experimental plots of the Imperial Economic Botanist, Pusa, were on several occasions sprayed or otherwise treated against aphids, termites, cutworms, rats, etc.

All entomological work for the Bihar and Orissa Department of Agriculture was attended to.

Fly and mosquito campaign was carried on throughout the year on the Pusa Estate.

Examination of Research papers, Schemes, etc.—Notes on about half dozen subjects were prepared and submitted to the Imperial Council of Agricultural Research. Seven research papers received from the Imperial Council of Agricultural Research, the Indian Lac Research Institute, Ranchi, the Zoological Survey of India and the Department of Zoology, University of Lucknow, were gone through and reported on.

The Second Entomologist visited Hyderabad to advise the Agricultural Department about the reorganization of their Entomological Section.

Issue of Certificates, etc.—Twenty-two samples of various seeds from the Imperial Economic Botanist, and the Imperial Agriculturist, Pusa, were fumigated and necessary certificates issued.

Bee-Keeping.—Information regarding Bee-Keeping was supplied to numerous enquirers. Standard bee-hives were got made locally for several applicants; queen-excluders and comb-foundation sheets for *Apis indica*, prepared in the Entomological laboratory at Pusa were supplied to fourteen different correspondents.

Coloured plates, etc.—A coloured plate of the Apricot chalcid fly was prepared and lent to the Director of Agriculture and Allied Departments, N. W. F. Province, Peshawar, for making lantern slides for campaign against this serious pest in his province.

About 400 coloured plates of different pests were supplied to various provincial entomologists, educational institutions and private individuals.

Donation of specimens—

23 specimens of Calliphorinae to Prof. W. S. Patton, Liverpool.

23 specimens of Diptera to the School Health Officer, Agra.

5 specimens of *Pempheres affinis* to Government Entomologist, Madras, Coimbatore.

150 specimens of Ticks to the Imperial Institute of Veterinary Research, Muktesar.

Two lots of Ephemeroptera and Odonata to K. A. Rahman, Zool. Lab. Cambridge, England.

34 specimens of Rhynohota, Ephemeroptera and Odonata to Prof. C. Strickland, School of Trop. Med., Calcutta.

Specimens of six species of Aphodiinae to Imperial Institute of Veterinary Research, Muktesar.

Specimens of important Insect pests of crops to Dr. J. K. Dubey, State Agricultural Department, Bhopal.

Loan of named specimens :—

Choenobius bipunctifer & *Etiella zinckenella* to the Prof. of Entomology, Agricultural College, Cawnpur.

Ichneumonidae to the Government Entomologist, Madras.

Specimens of Codling moth to the Agricultural Officer, Baluchistan, Quetta.

Dr. W. B. Gurney, Entomologist to the Government of New South Wales, visited the Section in June 1935 to discuss with the Imperial Entomologist the possibilities of importing a suitable Indian parasite of fruit flies into New South Wales. He consulted the collections and scientific records of the Section pertaining to fruit flies and other Indian pests.

Rai Sahib G. R. Dutt, Entomologist, C. P., Nagpur, worked in the Entomological Section for one week and consulted its Insect collections.

VII. PROGRAMME OF WORK FOR 1935-36.

This will follow generally on the lines of work of the previous year and will include special investigations of the pests of sugarcane, tobacco, fruit-trees, linseed and stored grains. An investigation of the biological standardization of various Insecticides will be started. Results obtained in various lines of work during the previous years will be written up for publication. The card catalogue of collections will be proceeded with. Advice and assistance will be given as far as possible to Provincial departments and to all enquirers on entomological subjects.

VIII. PUBLICATIONS.

Lists of publications on Indian Entomology for the years 1930, 1931, 1932 and 1933 were seen through the press and the List for 1934 was prepared and submitted for publication to the Imperial Council of Agricultural Research.

A paper entitled "Life histories of some Indian Thyrididae (Lepidoptera)" by B. B. Bose, Assistant, was submitted for publication.

REPORT OF THE IMPERIAL DAIRY EXPERT

[ZAL R. KOTHAVALLA, B.AG., B.SC. (AGRI.), N. D. D.]

I—INTRODUCTION

I held the post of the Imperial Dairy Expert throughout the year.

With the de-commercialisation of the farms at Bangalore and Karnal more attention is now being paid to the development of the other scientific and research activities. The transfer of a Chemist from Pusa to the Bangalore Institute has further added to the utility of the Institute, as besides the analytical work done in the laboratory the teaching efficiency of the students will be enhanced.

An evidence of the interest aroused in the public in the dairy industry is the increased number of inquiries received and the advice sought by them from the Imperial Dairy Expert's office. Two outstanding features of these inquiries were that some of the well-known cattle breeders of the country who were wanting their herds solely for the purpose of producing draft cattle have now turned their attention to the production of milk and requested for schemes to run their cattle breeding farms on dairy lines realising that with the changing conditions and the decreasing demand for purely draft cattle, organisation of the dairy industry must precede any efforts at cattle improvement in future. Another sign of the times is that most of the inquiries received from purely business men in the dairy line pertained to factory methods of handling milk and milk products and to knowledge and experience to be had in the manufacture of products like condensed milk, milk powder, etc. in order to utilise by-products like separated milk, butter milk, etc. which at present are more or less wasted. Material for helping the public in this direction is very limited at present and facilities for imparting training in such methods are more or less limited; so the new Imperial Research Creamery at Anand which has now been sanctioned will fill a long standing need for the development of industrial dairying in this country.

Karnal Farm.—The receipts of the farm during the year under review were less than the previous year by Rs. 13,856. This is accounted for by the sale rates of agricultural produce being lower than last year as also to the curtailment of farm cultivation operations owing to 118 acres of land which were under farm cultivation having been transferred to the Agricultural Section of the Imperial Institute of Agricultural Research. Rainfall during the year was normal. The breeding of pure bred Tharparkar and Hariana types of cows with a view to effect an improvement in their milk yield was continued during the year. The results so far achieved are that

the overall (dry period included) average yield during the year works out from farm-bred Tharparkar at 9.1 lb. and for Haryana 8.8 lb. as compared with the foundation stock purchased in 1923 when the overall average for both breeds worked out to 5.6 lb. There were no notable outbreaks of contagious diseases in the herd except a mild attack of Surra which was promptly brought under control. The mortality amongst the herd was normal.

Bangalore Farm—There was a reduction of Rs. 16,344 in the receipts of the farm as compared with the previous year due to the fall in the demands of milk from the British hospitals and the transfer of 14th Brigade from the station. The increased expenditure of Rs. 3,821 over the previous year is accounted for by the transfer of a Dairy Chemist from Pusa to take charge of the dairy laboratory at Bangalore and to higher rates paid for *ragi* straw, owing to the failure of rains in the season. The overall average during the year was 9.0 lb. for cows and 9.4 lb. for buffaloes. The health of the animals was good and the mortality amongst the herd was normal.

Wellington Farm—In spite of the reduction in the sale rates of dairy produce the farm worked at a profit of Rs. 6,690 during the year. Although the receipts were Rs. 1,247 less than the previous year there was an increase in the quantities of milk and butter sold during the period *i.e.*, milk 30,508 lb. and butter 1,061 lb. The outturn of farm crops was lower than the previous year due to less rainfall. The overall daily average of cows was 16.61 lb., *i.e.*, much more than Bangalore because only half bred cows from the Bangalore herd which are heavy milkers are sent to this place. The health of the animals was good except for some cases of abortion. This disease has been prevalent at Wellington for some years and the local veterinary authorities are doing their best to investigate the causes. Lately the veterinary authorities at Muktesar were also approached and the Director, Muktesar Institute is also investigating into the matter.

II—TRAINING AND EDUCATIONAL WORK

Out of the 21 students admitted to the Indian Dairy Diploma course in October 1933, 20 students continued to take the course. One repeat course student who failed at the Allahabad Institute in the last Indian Dairy Diploma examination was admitted on 1st June 1935. Three post-graduate students who were admitted to the course in January 1934 completed their training in March 1935. Of the two students who were admitted to the post-graduate course in January 1935, one left for Scotland for higher studies. Of the four short course students who were admitted for training during the year, two completed the course and the remaining two are continuing during the current year. Those who completed the training took a short course of post-graduate character. 15 British

soldiers admitted to the vocational training on 2nd February 1934 completed their training on 31st July 1934 and a fresh batch of 12 soldiers admitted on 1st August 1934 also completed the course on 31st January 1935. Another batch of 13 soldiers taken in April 1935 is continuing the training during the current year.

There was no examination of the Indian Dairy Diploma students at Bangalore this year as students are taken every two years, but an examination was held in December 1934 of the Allahabad students at that Institute and out of seven students who appeared five passed including one repeat course student from the Bangalore Institute.

III—ADVISORY AND PROPAGANDA WORK

Advisory work forms one of the main functions of this office, and during the year under review, advice was given on dairying and cattle-breeding and allied subjects to individuals, associations and Government officials in the following Provinces :—

Bombay Presidency	9
Madras Presidency	8
Bengal Presidency	11
United Provinces	11
Punjab including Kashmir and Malerkotla	13
Mysore State	2
Burma	4
Assam	1
Central Provinces	3
Malacca	1
Bihar and Orissa	2
Malay State	1
Coorg	1
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	67
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The above advisory enquiries emanated from the following sources :—

Government officials	13
Private individuals	39
Firms, associations and other organisations	15
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	67
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IV—EXPERIMENTAL AND RESEARCH WORK

The systematic selective breeding work of indigenous cattle, viz., the Hariana and the Tharparkar breeds and the buffaloes at the Imperial Cattle Breeding Farm, Karnal and the Scindi and Gir breeds and buffaloes at the Imperial Dairy Institute, Bangalore, was continued during the year. All the breeds have shown considerable improvement in type, conformation and performance.

The testing of milk of individual animals for fats and solids-not-fat from day to day was continued both at Karnal and Bangalore, and the statistics are being compiled from the tests on record.

Feeding experiments on the comparative effects of high and low protein rations to milch cattle were continued during the year in co-operation with the Physiological Chemist.

Other items of investigation carried out at the farms were as under :—

1. Systematic investigation work for standardising the method of making *Surti* cheese—one of the soft varieties of Indian cheeses.
2. Comparative study of the efficiency of sterilisation of dairy utensils and milk bottles by steam, catadyn water, and chemicals.
3. Study on the cultivation and yields of Guinea, Napier and lucerne grasses as fodder crops.
4. Study on the making of a barrow for carrying cans of milk.
5. Cheese experiments to study the relation of fat per cent. on milk to yield and quality of cheddar cheese.
6. Study of keeping quality of milk under different conditions such as milk at ordinary air temperature and in the cold stores ; also raw, chilled raw, pasteurised, heated or boiled, etc., to find out the best way to lengthen its life.
7. Comparative study of the efficiency of hand milking *versus* machine milking.
8. Study of the correlation of some points in body conformation with milk yield in Indian cows.
9. Body measurement and weight of cows in relation to milk yield.
10. Keeping quality of milk in relation to the kinds of vessels used, *e.g.*, of earth, glass, enamel, porcelain, etc.
11. Physical characteristics of fat in the milk of the various breeds of Indian cattle, both cows and buffaloes determined microscopically.
12. Prenatal treatment of heifers and cows to increase their milk yield and to facilitate easier handling when first coming into milk.

V—PUBLICATIONS

An article on "Indian buffalo as a milch animal in tropical countries" by Mr. Zal R. Kothavalla was submitted for publication in "Agriculture and Livestock in India".

An article "Study of the various standards adopted for the examination of Indian butter and ghee" by Messrs. S. D. Sunawala of the Indian Institute of Science and Zal. R. Kothavalla, was submitted for publication to the Imperial Council of Agricultural Research.

VI—CO-OPERATION WITH OTHER SECTIONS AND DEPARTMENTS

This section fully co-operated with the Physiological Chemist's Section in providing it with facilities required for its experimental work in the form of cattle, feed, etc. Also the help received from that Section in conducting various experiments, analysis of food-stuffs, etc. is much appreciated.

Thanks are due to the Mysore Civil Veterinary Department for arranging to protect the Bangalore herd against Rinderpest by the S. S. method inoculation free of charge. The Director, Imperial Institute of Veterinary Research, Muktesar, arranged for the inoculation of a large number of calves against Rinderpest by goat virus alone method. This method while being entirely safe has also proved to be more economical compared with the S. S. method. The help given by the Muktesar Institute is greatly appreciated.

VII—ADMINISTRATION OF FARMS

The following detailed reports from the Superintendents of farms are submitted. These reports have been commented upon in the introduction to this report.

Bangalore.—During the year 1934-35 the office of the Superintendent of this Institute was held by Mr. S. Cox.

The outturn of green fodder from the farm lands was very low as compared with the previous year. The outturn during the year was only 16,65,303 lb. as against 27,81,732 lb. in last year. The reduced outturn was mainly due to the failure of the monsoon thereby increasing the cost of production. The average rainfall at Bangalore used to be about 35 inches as recorded in this office but the rainfall for this year was only 21 inches and half of this fell in November 1934 when it was too late for the *Jowari* crop.

There was a drop in the sales of milk by 20,321 lb. as compared with last year's sales. This was due to less demands from the Military Hospitals during this year, as also to the removal of the 14th Field Brigade from this station. Wellington Institute was also supplied with 5,360 lb. milk during the year. There was however an increase in the sales of butter by 1,816 lb. and cream by 331 lb. due to the reduction in the rates of dairy produce introduced from 1st August 1934.

As this Institute has been decommercialised since 1st April 1933 and is now purely an educational and research institute, no financial accounts were prepared.

1. *Expenditure.*—A comparison of figures for three years is given below :—

1934-35.	1933-34.	1932-33.
Rs. A. P.	Rs. A. P.	Rs. A. P.
1,19,314 7 9	1,15,493 6 5	1,29,193 0 6

The increase in expenditure during this year was due to the creation of a post of Dairy Chemist who was transferred from Pusa and to the increase in the cost of *Ragi* straw purchased owing to the failure of monsoon.

Receipts.—Comparative figures for three years are given below :—

1934-35.	1933-34.	1932-33.
Rs. A. P.	Rs. A. P.	Rs. A. P.
76,082 3 11	92,426 7 9	1,16,560 10 3

The decrease in the receipts was due to less sales of milk and also to the reduced sale rates for dairy produce for 8 months in the year.

Sale rates of Dairy produce.

<i>Milk</i>	1934-35.	1933-34 and 1932-33.
	Per lb.	Per lb.
	Rs. A. P.	Rs. A. P.
Officers, Civilians, Troops and Hospitals	0 3 0	0 3 0
Married families	*0 2 0 0 2 6 *0 2 0	} 0 2 6
Issues at the Dairy in customers own vessel	0 2 6 *0 2 0	
Bulk for 50 lb. and above issues at the Dairy in customers own vessel	0 2 0	0 2 0
Bulk for 25 lb. and above issues at the Dairy in customers' own vessel	0 1 6	..
<i>Butter</i>		
Officers, Civilians, Troops and married families	1 4 0 *1 0 0	} 1 4 0
Civilians (from 5th February (a) 1933 to 31st May 1934)	1 8 0 & (a) 1 8 0 1 4 0 *1 0 0	
<i>Cream</i>		
Officers, Civilians, Troops and Married families	1 12 0 *1 0 0	} 1 12 0
<i>Cheddar Cheese</i>		
Whole cheese	1 4 0	1 4 0
	and 1 0 0	
On cut	1 8 0	1 8 0
	and 1 4 0	

Establishment—The expenditure under this head for three years was as follows :—

1934-35.	1933-34.	1932-33.
37,605 14 0	34,974 5 0	32,834 4 0

The excess expenditure during 1934-35 was due to the transfer of the Dairy Chemist from Pusa, and the employment of an extra Supervisor in connection with the vocational training of British soldiers.

*Rates reduced from 1st August 1934.

Cultivation—The same policy as in the past continues, *i. e.*, to keep under permanent green crop as much land as the water available for irrigation permits. This consists of about nine acres of Guinea grass, half an acre of Rhodes grass and two-thirds acre of lucerne. These crops usually give a continuous green fodder supply throughout the year, but during the year the outturn was less owing to the failure of monsoon.

The remaining cultivation area of about fifty-four acres is used annually for a monsoon crop, usually *jouari* which is utilised largely for silage making.

The only fodder purchased continually is *Ragi* straw, a crop which is not grown on the Farm. It could be grown but only at the sacrifice of *Jowar* which gives much heavier outturn. The outturn, etc. of fodder crops for the last three years are shown in the statement attached.

Three plots were sown to mixed maize and oats as a winter crop under irrigation and they were found to be a great success.

Several new kinds of grasses such as Teosinte, Sudan grass, Napier fodder, Paspalam, Italian Rye and Kulakuttai are being tried in experimental plots for the purpose of seeing their utility as well as for educational purposes. The I. D. D. students look after these plots.

Cattle—The herd maintained consists of crossbred cows, (*i.e.* those sired by imported Ayrshire bulls), Scindies, Girs and Murrah buffaloes. To increase the foundation stock of Gir Breeding, 7 Gir cows and one Gir Bull were purchased during the year.

The feeding of the adult herd is based on the starch equivalent contained in the mixed concentrates which consist of bran, groundnut oil cake, brewery grains, gram chunni and cotton seed oil cake meal in the proportion of 4 : 2 : 2 : 1 and 1. A pound of this mixture has a starch equivalent of .58 and the albuminoid ratio works out at 1 : 4.9. Based on the live weight of 700 lb. and giving milk of 4.2 butter fat a cow gets .26 starch equivalent per pound of milk yielded *plus* 3/4 lb. of oil cake for maintenance. Roughages are fed on a basis of 18 lb. dry matter fed as green fodder, silage or dry *ragi* straw in whatever proportions they are available.

The comparative overall averages of milk per day of all animals in the adult herd were as follows :—

	1934-35	1933-34	1932-33
	lb.	lb.	lb.
Cow (X Bred, Scindi and Gir.)	9.0	8.3	9.6
Buffaloes	9.4	6.8	11.6

The increased figure for this year as compared with last year was due to more young stock having been transferred to the adult stock, *i.e.* 47 against 21 in the last year, and also to the increase in the milk yields of these cows. There would have been a further

increase in the milk average had it not been for the transfer of certain good milkers to Wellington Institute in place of dry animals returned from there.

The increase under buffaloes was due to the increase in the yield of 3 young buffaloes transferred from Karnal.

The following figures show the merit of the different classes of animals.

	X Bred.	Scindi.	Gir.	Buff.
Average daily number in herd milking	51.1	43.9	8.4	7.3
Ditto dry	18.1	33.0	6.6	4.4
Average milk yield per animal which completed its yield during the year in lb.	4593.6	2758.5	2594.7	5089.2
Average number of days in milk of the same animals	328.4	254.9	270.3	324.2

As the breeding policy is to improve the Indian breeds and to do away with the cross-bred herd gradually, the Scindi and Gir cows are crossed only by selected bulls of their respective breeds. Half of the $\frac{1}{2}$ -bred cows (good milkers) are served by Ayrshire bull and the other half by pedigreed Scindi bulls and so also in the case of $\frac{1}{2}$ -bred young stock. $\frac{3}{4}$ Ayrshire or Hol. Scindi and Sahiwals are served by pedigreed Scindi Bulls and $\frac{1}{4}$ -bred Ayrshire or Hols. Scindi are served by Ayrshire bull.

Of the 25 cows and 56 young stock (male and female) sold during the year the majority were of cross-bred type.

The quantities of milk produced were :—

Cows	lb.
Buffaloes	5,27,916
	40,881

Young Stock—The number of farm-bred heifers which joined the adult herd during the year was as follows :—

Cross Bred	31
Scindi	16

Rearing of Calves—The number of calves born at this Farm during the year was as follows :—

	Cow Y. S. Female.	Cow Y. S. Male.	Buffaloes (Murrah) Male.	Female
Scindi	31	43	6	2
X Bred	42	47		
Gir	2	6		

The male calves dropped by cross-bred cows are given away soon after birth and the number so disposed of was 41. Of the remainder cross-bred calves, 2 male calves and 6 female calves were sold and 7 female calves died. Calves of Indian breed are reared for stud purposes and for the purpose of improving the Indian breed. Calves of cross-bred animals are weaned at birth and also Scindi and Gir heifers. All such calves are hand reared commencing with a ration of new milk and later supplemented by separated milk and grain rations.

Diseases—There was no outbreak of contagious diseases during the year. The casualties were small when compared to last year. The deaths during the year 1934-35 were as follows :—

Country cows	.	.	.	.	.	.	.	.	5
Cross-bred	.	.	.	.	.	.	.	.	4
Cow Y. S. female	.	.	.	.	.	.	.	.	21
Cow Y. S. male	.	.	.	.	.	.	.	.	5
Buffalo Y. S. female	.	.	.	.	.	.	.	.	1

The adult animals died from various causes, such as Broncho-Pneumonia, Heart failure, Impaction of the third stomach and expulsion of uterus, etc., and the young stock died of diarrhoea, dysentery, etc.

The Institute was visited during the year by a large number of students from different schools and colleges.



Statement showing outturn of fodder grown on the farm lands during the year 1934-35 at the Imperial Dairy Institute, Bangalore, and the attached dry stock farm at Bommanpally with figures for 1932-33 and 1933-34

Where grown	1934-35			1933-34			1932-33		
	Kind of fodder	Acreage	Outturn in lb.	Cost per 100 lb.	Outturn in lb.	Cost per 100 lb.	Outturn in lb.	Cost per 100 lb.	
BANGALORE	Green <i>jowari</i> .	53.87	6,20,620	Rs. A. P.	12,06,400	Rs. A. P.	15,60,340	Rs. A. P.	
	Lucerne .	.79	65,398	0 6 3	84,427	0 3 4	96,448	0 2 2	
	Guinea grass .	9.49	18,04,660	0 9 1	11,90,965	0 5 9	9,68,460	0 4 11	
	Rhodes .	}	3,040	0 4 3	54,560	0 2 9	79,600	0 3 2	
	Napier grass .				0 2 4				
	Maize and oats								
	Berseem .								
	Sudan grass .	.41	41,280	0 6 1					
	Total	64.56	15,53,703	0 5 4	25,36,352	0 3 1	27,04,848	0 2 7	
	Green <i>jowari</i> .	..	1,11,600	0 6 0	2,40,380	0 3 0	2,83,355	0 1 10	
Guinea grass .	..	..	..	5,000	0 0 4	8,400	..	
Total	..	1,11,600	0 6 0	2,45,380	0 2 11	2,91,755	0 1 9		
GRAND TOTAL .	64.56	16,65,303	0 5 4	27,81,732	0 3 1	29,96,603	0 2 6		
BOMMANPALLY									

Wellington—Mr. M. C. Rangaswamy, I. D. D., Supervisor was in charge throughout the year.

The working of the Institute resulted in a profit of Rs. 6,690 against a profit of Rs. 7,738 during 1933-34 and a profit of Rs. 6,629 during 1932-33.

The figures given above will show that the farm has continued to work at a profit during the year inspite of the reduction in the sale rates which were given effect to during the course of the year.

This is due to a considerable increase in the sales of dairy products to the Military and the general economies effected.

The rainfall during the year was considerably less than the previous years, both during *Kharif* and winter seasons. To add to this the falls were very irregular. The frost during the year was as early as November.

Rainfall compared for three years :—

1934-35	26.04
1933-34	41.25
1932-33	50.34

Capital—The following table shows the value of capital assets at the beginning and close of the year.

Particulars	Value on 1st April 1934	Additions during the year	Total	Condem-nations and transfers	Depre-ciation	Casualties	Value on 31st March 1935
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Land	10,919	...	10,919	...	...	...	10,919
Buildings	84,769	316	85,075	...	1,216	...	83,859
Plant and Ma-chinery	5,800	347	6,147	...	969	...	5,178
Live Stock	1,050	250	1,300	215	...	130	955
	1,02,528	913	1,03,441	215	2,185	130	1,00,911

Receipts—The comparative figures of receipts for the last three years are set out in the table below :—

Produce	1934-35		1933-34		1932-33	
	lb.	Rs.	lb.	Rs.	lb.	Rs.
By sale of—						
Milk	1,50,199	22,121	1,19,691	22,451	1,34,966	26,060
Butter	16,976	17,729	15,915	18,507	17,706	22,138
Cream	543	700	529	927	430	758
Separated milk	53	3	150	9	410	14
Butter milk	136	2	100	2	153	2
Cheese	88	94	...	...	...	...
Total	...	40,649	...	41,896	...	48,967
Miscellaneous	...	1,967	...	2,040	...	2,247
Grand Total	...	42,616	...	43,936	...	51,214

All the items of receipts show a reduction as compared with those of the preceding two years. This is due to the reduction in the sale rates of dairy produce during the course of the year. It

will be noticed that in spite of the increased sales of the dairy products as compared with the last two years the amount realised was lower owing to the reduction in the sale rates.

The following table shows the sale rates of dairy produce for the past three years :—

Produce	1934-35			1932-33 and 1933-34		
	Rs.	A.	P.	Rs.	A.	P.
Milk to officers, troops, Regimental Institutes and Hospitals	0	3	3			
	&					
	0	2	0	0	3	0
Married families	0	2	6			
	&					
	0	2	0	0	2	6
Butter to all	1	4	0	1	4	0
	1	0	0			
Cream to all	1	12	0	1	12	0
	1	0	0			
Separated milk to all	0	1	0	0	1	0

The sale rates during the year under review were reduced on the understanding that the troops stationed at Wellington obtain their full requirements from the Wellington Institute. This had the desired effect as there was an increase in sales.

Establishment—Comparative costs of establishment for the last three years are shown below :—

Particulars	1934-35	1933-34	1932-33
	Rs.	Rs.	Rs.
Supervisor in charge	1,674	1,540	1,515
Permanent staff	4,048	4,034	3,461
Temporary staff	5,337	5,351	5,511
Total	11,059	10,925	10,487

The increase in the expenditure was due to the grant of annual increments to the staff and the reduction of the emergency cut in salary from 10 per cent. to 5 per cent. since the year 1933-34.

The following table shows the quantities of butter produced from purchased cream and the comparative prices per pound for the last three years :—

Years	Purchased quantity	Price			Home produced quantity	All-in-cost		
		Rs.	A.	P.		Rs.	A.	P.
1934-35	10,990	0	12	0	420	3	8	6.65
	6,494	0	11	0				
1933-34	9,947	0	13	0		3	15	2.76
	5,273	0	12	0	530			
1932-33	15,957	0	13	7		4	9	7.04
					1,805			

(a) *Purchased butter*—The increase in the quantity purchased was due to more butter trade with the Military.

(b) *Home produced butter*—As the cost of producing home butter will always be more than the purchased butter, its manufacture is restricted to the minimum possible taking into consideration the varying demands for milk from the military.

It may be mentioned here that the all-in-cost of purchased and home butter both combined for the year works out to Rs. 0-13-7·31 against the selling price of Rs. 1-4-0 and Rs. 1 per pound prevailing during the year.

Cultivation—The table given below shows the particulars of land in acres owned and leased by this Institute during the year under review :—

Particulars	Land. Total acreage	Arable		Grazing	Forest for fuel	Buildings and roads	Leased out
		Perennials	Seasonal crops				
Owned . . .	68·85	5·00	25·50	24·26	7·00	6·08	...
Leased . . .	40·00	...	10·00	...	...	...	80·00
Total . . .	108·84	5·00	36·50	24·26	7·00	6·08	80·00

The following table shows how the arable land was distributed for cultivation and the rotation that was followed :—

<i>Kharif</i>	Acres	<i>Rabi</i>	Acres
Green grass, lucerne, Rhodes & guinea grass . . .	5·00	Rhodes and guinea grass and berseem . . .	5·00
Potatoes	4·50	Potatoes	2·50
Jowar	12·75	Oats and peas	10·25
Maize	9·25	Oats	21·75
Ragi	10·00	Ragi	2·00
Total	41·50	Total	41·50

Out of the 40 acres leased land only 10 acres were utilized by the farm for fodder crops and the balance of 30 acres which the farm could not make use of were leased out on cash rental for cultivation purposes. The supply of green fodder from the area sown was sufficient to meet the requirements of the farm.

Although the rainfall was considerably less than previous years, both *rabi* and *kharif* crops grew fairly well and in order to get enough green fodder, peas, horse gram and oats and peas mixed were also tried.

The table given below shows the comparative yields of crops for the last three years :—

Crops	1934-35 lb.	1933-34 lb.	1932-33 lb.
Rhodes and Green grass	77,265	1,37,270	1,38,555
Lucerne	3,280	5,001	15,435
Maize	92,550	91,500	1,08,990
Oats	76,970	48,300	58,140
<i>Bagi</i>	11,390	56,650	1,700
Gram	9,340	4,400	..
<i>Jowar</i>	1,01,650	1,44,700	1,26,655
Wheat . . . . .	..	52,415	11,535
Berseem	1,845	3,510	..
Barley . . . . .	..	17,700	..
Peas	1,150	..	..
Oats and peas mixed	55,870	6,150	..
Cow Peas	2,050	..	..
Mangolds . . . . .	..	3,300	520
<i>Bajra</i> . . . . .	..	..	19,900
Sun flower . . . . .	..	..	2,400
Cabbage . . . . .	..	..	8,800
Total	4,33,340	5,70,896	4,92,630
Potatoes (Cash crop)	47,368	58,500	33,384
Total	4,80,708	6,29,396	5,26,014

Jowar and maize are found to be the most suitable crops for the *khari* season both for green issues and silage making and oats and peas mixed for the *rabi* season. These crops give large yields and are economical to grow. During the year under review green fodder was produced at Re. 0-8-0-6 per hundred pounds against the market rate of about Re. 1 (One) per hundred pounds. Owing to the failure of monsoon the expenditure in raising the crops with irrigation etc. increased.

The growing of potatoes being beneficial to the farm, it was again tried both in the *khari* and *rabi* seasons. It is very helpful in the elimination of weeds and thus the other crops thrive well and it is also a paying crop. During the year an outturn of 6,767 pounds per acre was obtained at a production cost of Rs. 1-13-9 per 100 pounds against Rs. 1-8-3 in 1933-34.

Cattle—This farm under orders of Government is considered as a depot, cows in milk being supplied from Bangalore to Wellington as required and returned to Bangalore when dry.

The table below gives a comparison of :—

- (1) Milking average per diem per head of milking cows, and

(2) Overall average of the year with the figures of the preceding year—

							Milking average per diem per head of milking cow	Overall average
1934-35	:	:	:	:	:	:	18·65	16·61
1933-34	:	:	:	:	:	:	17·50	16·10

There is a slight increase in the average yield of cows per day.

The comparative production cost per pound of milk for the last three years is given below :—

								Per pound.
								Rs. A. P.
1934-35	:	:	:	:	:	:	:	0 2 7·9
1933-34	:	:	:	:	:	:	:	0 3 1·2
1932-33	:	:	:	:	:	:	:	0 2 9·9

The cost price of milk shows an improvement over those of the previous years. This is due to the increase in the yield of milk and other economies effected in the expenditure. It should also be noted that the production cost is worked out "all in costs" meaning that it includes all indirect charges such as audit fees, direction charges, leave and pension contribution and interest on capital. These charges for this year alone amounted to Rs. 5,322. These charges do not appear in the Cash Account but for purposes of production cost they are added to the Expenditure. The costs of production exhibited are therefore more than what they would be if the above charges are left out.

The general health of the herd was good throughout the year. There were cases of abortion amongst cows. The investigation work on these abortions was taken up by the Madras Veterinary Department and is still being conducted. The Director, Imperial Institute of Veterinary Research, Muktesar, is also investigating into this matter. All necessary precautions are being taken.

Karnal

Mr. A. Lamb proceeded on leave on 13th April 1934 and was relieved by Mr. Harnam Singh who remained in charge until 12th December 1934 when Mr. A. Lamb returned to duty again.

There were no great variations in the prices realized by the sale of surplus crops. Rates for dairy produce remained regular throughout the year.

The total rainfall for the year was about normal, i.e., 31·43 inches, of which 26·9 inches fell in July and August. The expenditure and receipts for the last 3 years were as follows :—

		1932-33	1933-34	1934-35
		Rs.	Rs.	Rs.
Expenditure	.	73,060	65,105	68,015
Receipts	.	48,921	43,336	29,480
Net Cost	.	24,139	21,769	38,535

The higher cost in 1934-35 is due to the land leased on cash rental being less in area and at a lesser rate; less outturn of ziri due to the area sown being less, extra temporary establishment employed from December to February, expenditure on special repairs to the Depot Minor, refund of rent caused by floods in 1933-34, and the number of trees sold being less. The comparative sale and purchase prices are given below :—

SALES

Crop	1933-34		1934-35	
	Rs.	A. P.	Rs.	A. P.
1. Wheat per maund	2	9 6	{ 2 7 2 2 7 3	
2. „ Machine thrashed	{ 2 7 4 2 6 1 }		2 6 7	
3. „ „ „ „ „ „	1 11 3		..	
4. „ and gram mixed . . . . .	..		1 12 2	
5. Gram	1 13 0		1 8 2	
6. „ machine thrashed	1 9 6		..	
7. Rice (ziri)	1 9 5.4		1 10 4.165	
8. Mustard seed	2 5 1		..	
9. Wheat <i>bhoosa</i>	0 6 9		0 3 6	

PURCHASES

Name of concentrates	1932-33	1933-34	1934-35	
	Rs. A. P.	Rs. A. P.	Rs. A. P.	
1. Bran . . . per maund	1 8 11	1 14 11	1 13 2	per 100 lb.
2. Barley . . . „	1 9 4	1 7 0	& 2 3 11	„
3. Linseed cake . . . „	2 3 6	2 0 0	1 13 3.2	„
4. Salt . . . „	2 12 10	2 10 9	& 1 15 10	„
5. Feeding flour . per cwt.	11 0 0	10 0 0	3 1 3	„
			3 10 0	„
			10 0 0	„

The usual annual depreciation of capital assets was the cause of reduction of capital as also the transfer of 118.17 acres of land to the Agricultural Sub-station.

The contract rate for surplus milk sold to a local contractor was higher than the previous year.

The comparative figures of sale rates of dairy produce are given below :—

	1933-34		1934-35	
	Rate per lb.		Rate per lb.	
	Rs. A. P.	Rs. A.	Rs. A. P.	Rs. A.
Fresh milk retail	0 0 9		0 0 9	
Fresh milk on contract	0 0 5.85		0 0 7.2	
Butter	1 0 0 to 1 4		1 0 0 to 1 4	
Cream	0 12 0 to 1 0		0 12 0 to 1 0	
Cream on butter outturn	0 9 6 to 0 10		0 9 6	
Ghee	0 6 0 to 0 9		0 9 0	
Separated milk	9 0 3		None sold.	
Cheese	1 2 0		1 2 0	

The cost of establishment compared with the previous year was as under :—

	1933-34	1934-35
	Rs. A. P.	Rs. A. P.
Pay of Officers	3,258 11 0	3,491 4 0
Pay of Establishment.		
Pay of Assistant Superintendent, Indian Supervisors, Accountant, etc. . .	15,857 1 0	16,420 15 0
Pay of Permanent non-pensionable establishment	1,418 8 0	1,444 1 0
Pay of temporary establishment . .	13,354 14 0	13,982 5 0
Leave salary	1,226 2 0	542 0 0
Total	35,115 4 0	35,880 9 0

The sales of dairy produce for the last 6 months of the year as compared with the previous year are shown below :—

This is the period during which butter is sent to Delhi twice weekly.

	Milk	Butter	Separated milk	Cream	Ghee	Cheese
From October 1933 to March 1934 . .	2,993	2,238	..	445	1,489	30
From October 1934 to March 1935 . .	2,044	809	..	3,030	14	..

The Military Farms Department resumed taking cream for butter making with the result that very little ghee was made.

CULTIVATION

This Farm possesses 1,981·5 acres of land under its control out of this, 89 acres are non-cultivable (waste land), 262 acres were leased on cash rent by public auction for grazing and cultivation for one year, 182 acres were reserved for grazing by Farm livestock, and 257 acres are occupied by roads and buildings.

118·5 acres were under home cultivation during the first half of the year but in the second half year the whole of that area was transferred to the Agricultural Section of the Imperial Institute of Agricultural Research for the establishment of an Agricultural Sub-station. 1,073 acres were leased out on ' batai ' system for one year from the usual date, i.e., 15th June.

ROTATION

Of the 118·5 acres under home cultivation as mentioned above about 61 acres were sown with *Jowar* for silage making and the rest remained fallow till it was handed over in October to the Agricultural Section.

Batai Plots 2, 3, 4 and 5 :—Half was put down to *Jowar* and the other half fallowed for wheat in the winter.

Batai Plots 6 and 7 :—Half was sown with rice and the other half remained fallow during the *Kharif* season for the purpose of ploughing for destruction of weeds.

Crops.—*Jowar* and Rice were the two *Kharif* crops. Home *Jowar* was harvested green mainly for silage making. During the cutting operations green *Jowar* was fed green and a small portion reserved for dry fodder. The total green *Jowar* produced was 24,18,817 lb. Of the *Batai Jowar* the farm share was sold by auction as a standing crop—it being too scattered about the farm to utilise it for farm purposes.

Plots 6 and 7 being low lying and largely under water in the monsoon are only used for rice during that season.

The monsoon commenced with a few very light showers at the end of June. The first heavy rain which fell on 2nd July was 7·86 inches. The rains stopped early giving very light showers in September and therefore all the area under *Rabi* was sown by canal irrigation and this was also too late as the Agricultural and Botanical Sub-stations were to be given preferential treatment in so far as canal irrigation was concerned.

The record of rain as obtained from the Botanical Sub-station rain gauge is :—

June	July	August	Sept.	Jan.	Feb.	March	April	Total for year
0·86	16·94	9·97	0·43	2·57	1·27	0·54	0·95	31·43

The wheat crop was not irrigated from the time of sowing until late in March owing to the main canal as well as the Depot Minor being closed for repairs. Light showers in January and February helped to some extent but with cloudy weather in March and April rust appeared and caused damage, the variety P. 111 in Plot No. 4 *Batai* being most affected

As the wheat-Punjab 8A had proved very susceptible to disease, its cultivation was abandoned and a number of Pusa wheat were grown. The outturn from various plots of different varieties are as follows and of which the farm share was one-half.

Plot	Area Acre	Variety P.	Outturn		Average outturn per acre Mds.
			Mdr.	Srs.	
2	43·2	80·5	481	16	10·12
3	43·3	80·5	403	14	8·14
4	52·8	111	410	12	6·16
5	47·2	120	496	36	10·4
	26·07	114	142	2	4·14
	23·5	165	215	4	8·10

The best variety was P. 80-5 both from the point of view of quantity and resistance to disease but being beardless it was eaten by pigs and birds. P. 111 was badly damaged by rust while P. 114 and 165 were slightly affected. P. 120 was affected with flag smut. All yields, however, were very low due to the 'batai' system and the plots being in bad condition.

Gram and barley were sown after *Jowar* and rice and also after fallow in the rice plots (6 and 7). The low outturns of grain are partly due to disease in wheat and partly to early stoppage of monsoon and late sowing caused by the difficulty in obtaining water in time.

	Acreage	Outturn		Average
		Mds.	Srs.	outturn
Wheat	285.30	2,321	14	8.14
Gram	486.27	4,452	9	9.16
Barley	188.69	1,173	7	6.20
Oats	69.71	487	26	6.96
Rice	279.26	3,605	21½	12.92
Green <i>Jowar</i>	61.6	2,426,074	lbs.	39,130 lbs.

Hay and silage making:—The first cutting of grass from Plot 8 was converted into silage and the second cutting into hay. In other grass areas the crop was scanty due to monsoon conditions already pointed out and only silage was made. The total produce was 934,722 lb. grass silage and 29,766 lb. hay. A comparative yield of crops for the last 3 years is shown below:—

—	1932-33	1933-34	1934-35
	lb.	lb.	lb.
GRAIN			
Rice (<i>Ziri</i>)	266,500	216,972	144,187
Wheat	301,760	157,604	161,242
Oats . . . . .	..	4,510	27,388
Gram	469,942	285,442	286,155
Mustard	3,280	..	..
Wheat and gram mixed . . . . .	..	..	479
Barley . . . . .	..	..	7,097
FODDER			
Green <i>Jowar</i>	276,164	16,200*	64,257
Dry <i>Jowar</i> . . . . .	..	39,770	5,800
Green oats . . . . .	..	..	12,352
Green maize	40,657	..	..
Dry maize	7,180	..	..
Gram stalks . . . . .	..	..	87,022
Hay	118,476	227,332	29,766
<i>Bhoosa</i> (gram, wheat, barley and oats.)	698,694	652,909	518,697
Rice straw	272,404	215,250	138,150
<i>Charri</i> silage	1,551,840	940,836	1,765,920
Grass silage	168,388	364,300	718,912(a)
Anjan grass seed	53	..	9½
Grass fed green	14,378	..	..
<i>Poolas</i> (Thatching grass)	6,601	..	..

* Major part sold standing.
(a) 215,810 lb. overestimated—not included.

CATTLE BREEDING

Livestock figures at the beginning and end of the year were as follows :—

	1st April 1934	31st March 1935
Cows	129	146
Buffaloes	15	9
Cow bulls	9*	9
Buffalo bulls	2	1
Cow calves and youngstock females	115	124
Cow calves and youngstock males	51	74
Buffalo youngstock females	9	9
Buffalo youngstock males	5	5
Bullocks	29	28
Horse	1	1
Sheep—		
Ewes	66	76
Rams	4	7
Female lambs	52	58
Male lambs	5	5
Total	492	552

* Includes 1 Stud bull on loan from Delhi.

No animals were purchased during the year.

	Male	Female	Total
<i>Births—</i>			
Tharparkar	37	36	73
Hariana	31	29	60
Buffalo calves	3	3	6
	T. P.	Har :	Total

Transfers from youngstock to adults—

Cow Females	16	13	29
Cow Males	1	Nil.	1
	(Stud Bull)		
Buffalo females	2	..	2

Disposals—

(1) Cows	10	On account of old age, incurable disease or poor yields.
Cow female youngstock	3	} Not conforming to type and colour or in other respects below standard.
Cow male youngstock	11	
(2) Buffalo bull	1	Sold to a private institution.
Buffalo youngstock males	3	Sold to Agricultural Department U. P. for breeding purposes.
(3) Buffaloes	8	Transferred to Bangalore Farm.
(4) Cow female calves	17	} Disposed of at birth or at an early age for the following reasons :—
Cow male calves	27	
Buffalo female calf	1	
		(a) Low record of dam.
		(b) Not conforming to type.
		(c) Colour defects.
		(d) Under weight at birth.
		(e) Physical deformations.

Rejection of young calves has been carried out during the year on the above lines, to avoid condemnation at a later age, thus minimising the expenditure in upkeep. A few calves of light red colour of both sexes from good yielding dams were retained for purposes of observation as to the possibility of subsequent changes in colour.

Mating of adult stock was regulated from 2nd heat to 3 months after calving, keeping in view, age, milk yield, and the general health of animals. Heifers were not put to bulls until the age of 2½ years and young bulls brought into service at 3½ years of age.

Feeding of stock was done according to the scale of feed sanctioned by the Imperial Dairy Expert.

Comparative over-all averages of different breeds for three years :—

Year	Tharpar- kar	Variation Per cent.	Hariana	Variation Per cent.	Buffaloes	Variation Per cent.
1932-33	9.3	..	8.4	..	13.0	..
1933-34	9.4	+1.0	8.6	+2.0	11.8	-9.0
1934-35	9.8	+4.0	9.0	+4.4	10.1	-14.4

The drop in buffaloes yields is accounted for by (1) transfer of the best animals to Bangalore. (2) advanced age of present stock (3) new heifers have yet to complete their lactations.

Records of six of the best animals of each breed which completed their lactation during the year are given below :—

Serial No.	Animal No.	Age Yr. M.	Milk Yield lb.	Days in milk	Remarks
THARPAR-KAR					
(1)	119	15 0	7,249	391	Purchased 1925
(2)	262	9 7	6,059	412	Farm bred
(3)	266	10 0	6,117	357	Purchased
(4)	323	8 8	5,387	308	Farm bred
(5)	378	6 9	6,597	334	" "
(6)	387	7 10	5,720	297	" "
HARIANA					
(1)	186	11 5	6,985	307	Purchased 1926
(2)	302	8 11	6,864	366	Farm bred
(3)	348	8 4	6,634	316	" "
(4)	383	8 2	5,713	315	" "
(5)	414	7 2	5,580	447	" "
(6)	419	6 11	6,535	419	" "
BUFFALOES					
(1)	19	13 0	6,503	308	Purchased 1926
(2)	21	9 4	5,662	253	Farm bred
(3)	25	13 0	4,532	293	Purchased 1929
(4)	33	8 7	5,399	399	Farm bred
(5)	52	6 6	4,088	371	" "

BREEDING

The main object is to fix a high milking standard, while conforming to breed, type and colour.

The results attained as compared with the purchased basic stock is shown by the following table which has been calculated from all

completed lactations (568 T. P. and 424 Har :) since 1923 :—

	Tharparkar		Hariana	
	Purchased	Farm bred	Purchased	Farm bred
Average milk yield lb. .	2,294	3,791	2,379	3,634
" lactation period (days).	242	311	255	304
" dry days .	147	95	150	106
" over-all (dry period included)	5.6	9.1	5.6	8.8

Average milk yield of animals which completed their lactations in 1934-35 :—

No. of animals	Average milk yield lb.	Average days in milk	Average days dry
Tharparkar . . . 66	3,441	265	102
Hariana . . . 57	3,538	297	123
Buffaloes . . . 6	5,090	309	152

Rearing of calves

The system of weaning at birth was strictly followed except in special cases where a few farm-bred animals have failed to give milk up to the standard in their first or second lactations, although descending from high milking parents.

Results of such experiments in cows were as follows :—

Cow No.	Breed	Milk yield in lb. and days			Remarks
		Best weaned	Not weaned		
215	T. P. .	3659 (4) 288	5588 (6) 306	4456 (7) 253	Top figures denote milk in lbs. and bottom figures No. of days. Numericals in brackets denote No. of lactations.
313	" . .	2796 (3) 218	3446 (4) 325	2043 (5) 184	
342	Har : .	2629 (2) 249	4426 (3) 303	3417 (4) 265	
			3230 (5) 230		
373	Har : .	3861 (1) 278	2733 (4) 197		
386	" . .	2430 (3) 182	2604 (4) 184		
413	" . .	2022 (2) 206	2574 (3) 225		

All weaned calves upto one month old get only mother's milk fed from the pail and afterwards pure milk is gradually substituted by separated milk in addition to a small portion of concentrates and fodder upto 6 months, thereafter separated milk upto one year in addition to concentrates and fodder.

Mortality.—

Cow calves	13	Pneumonia, Dysentery, Fits, Joint ill, Dip poisoning, Hoven.
Buffalo calf	1	Pneumonia.

Following deaths occurred during the year :—

Diseases.—

Cows	2	1 old age and 1 destroyed for incurable disease.
Cow bull	1	(Snake Bite.)
Cow youngstock male	2	(H. S. and Pericarditis.)
Bullocks	2	(1 poisoned while grazing, 1 destroyed incurable sprain in lumber regions.)

The only outbreak of contagious disease in the herd was 2 cases of surra in calving stock and by timely treatment they recovered. After an examination by the Veterinary Investigation Officer, Punjab, one more cow in the herd was traced as being a carrier of surra and an injection was given under his instructions.

Preventive inoculations for rinderpest were carried out by the staff of the Imperial Institute of Veterinary Research, Muktesar in March.

The following 76 animals were treated :—

	S. S. Method	Virus alone
Cows	5	..
Buffaloes	1	..
Cow bull	1	..
Bullocks	9	..
Cow male youngstock	3	25
Cow female youngstock . . . . .	..	31
Buffalo male youngstock . . . . .	..	1
	<hr/> 19	<hr/> 57

Sheep.—Comparative average production of wool in sheep per head for last 3 years, which now consists of farm-bred stock only was as follows :—

Year	Average production	
	lb.	oz.
1932-33	4	7
1933-34	5	1
1934-35	5	9

Deaths during the year.—9 (gid, grazing poisoning and other causes).

EXPERIMENTS, RESEARCH AND DEMONSTRATION

Milk tests to determine the quantities of butter fat and total solids in milk were conducted for the combined herds of cows and

buffaloes on the farm and also for individual animals of all breeds under the following heads :—

- (1) Combined herd tests for each breed of cows and buffaloes, daily morning and evening.
- (2) First calves of all the breed for one complete lactation, daily morning and evening and also for these animals which have not been tested before for one full lactation.
- (3) Weekly composite tests for the animals which completed one full lactation under daily tests.
- (4) Alternative day tests which were started last year, were stopped in favour of above.

Number of animals under testing during the year

Description of test	Tharparkar		Hariana		Buffaloes	
	1st April 1934	31st March 1935	1st April 1934	31st March 1935	1st April 1934	31st March 1935
Daily .	18	13	15	12	1	4
Weekly .	16	36	14	27	..	3
Total .	34	49	29	39	1	7

Total on 1st April 1934 .	:	:	:	:	:	64
Total on 31st March 1935	:	:	:	:	:	95

Determination of outturn percentages of different by-products of milk such as cream, butter and *ghee* which commenced in the previous year was continued throughout the year.

Attached statement No. 1 gives some idea of the variations of butter fat, specific gravity and total solids in milk during the different seasons. Highest percentage of fat was produced by cows in the first quarter of the year (April to June).

Statement No. 2 shows the feed cost per animal per year and the quantity of fat produced against it.

3 Post-graduate students were here for two months and they were shown the following operations :—

- (1) Homogenization and sterilization of milk.
- (2) Butter making.
- (3) *Ghee* making by modern (Steam Jacket) and country method.
- (4) Casein making by—
 - (a) Rennet coagulation
 - (b) Acid coagulation
 - (c) Natural curdling

The Farm was visited by the following, who were shown around :—

Students from the Agricultural College, Lyallpur.

B. So., Agricultural Class of the Khalsa College, Amritsar.

A demonstration of the dairy section was arranged at the local Health and Baby Week.

No. 1.—Particulars of combined herd testing during the year 1934-35

Month	Average No. of cows daily.	Tharparkar Herd					
		Average B. F. test per cent.		Average Specific gravity		Average Total Solids per cent.	
		M.	E.	M.	E.	M.	E.
April 1934 . . .	43	4.6	5.2	31.1	30.1	13.54	14.05
May	43	4.6	5.1	30.4	29.6	13.34	13.75
June	41	4.7	5.0	30.0	29.5	13.42	13.56
July	41	4.5	4.6	31.2	30.4	13.41	13.31
August	42	4.5	4.5	32.4	31.4	13.79	13.51
September . . .	45	4.4	4.4	32.8	31.7	13.49	13.40
October	40	4.4	4.8	32.0	30.0	13.50	13.41
November	45	4.4	4.9	31.3	30.0	13.36	13.69
December	51	4.3	4.9	33.2	31.7	13.82	14.03
January 1935 . .	52	4.3	4.8	33.1	31.5	13.66	13.96
February	50	4.2	4.9	33.1	31.7	13.56	14.10
March	51	4.3	4.7	33.1	31.8	13.60	13.82
HARIANA HERD.							
April 1934 . . .	37	4.6	5.3	31.5	30.2	13.61	14.20
May	39	4.4	5.1	30.8	30.0	13.23	13.77
June	38	4.5	4.8	30.6	29.8	13.22	13.51
July	39	4.3	4.5	31.5	30.8	13.34	13.24
August	40	4.5	4.5	32.6	31.9	13.88	13.59
September . . .	40	4.5	4.5	33.0	32.0	13.90	13.63
October	41	4.4	4.7	31.9	30.4	13.54	13.54
November	40	4.4	4.9	31.4	30.1	13.38	13.73
December	41	4.3	4.9	33.2	31.6	13.68	14.08
January 1935 . .	41	4.2	4.8	33.2	31.7	13.61	13.97
February	41	4.3	4.8	33.1	31.7	13.71	13.98
March	42	4.2	4.6	33.5	32.3	13.70	13.91

Statement No. 2

Daily average of milking stock fed during the year (2 breeds of cows)	Daily average cost of feed (for column 1)	Average cost of feed per animal for the year	Number of animals completed lactation under weekly composite tests	Total amount of fat produced by animals (column 4)		Average quantity of fat produced per animal (column 4)	
				T. P. lbs.	Har : lbs.	T. P. lbs.	Har : lbs.
1	2	3	4	5		6	
	Rs.	Rs.					
135	32 8 0	88	37 33	4,759	4,970	128·6	150·6

N.B.—To arrive at the average cost of feed per animal per year (Column 3), the averages have been taken for all the milking stock including dry and calving stock animals (Columns 1 and 2), and to arrive at the average quantity of fat produced per animal (column 6), the animals under column 4 have been taken into consideration.

REPORT OF THE PHYSIOLOGICAL CHEMIST

(A. VISWANATHA IYER, B.A.)

I.—CHARGE

Dr. Warth was in charge of the Section up till the 15th March 1935, when Mr. A. Viswanatha Iyer, Assistant Physiological Chemist, took over charge.

II.—RESEARCH

1. EXPERIMENTS ON MILK PRODUCTION

High and normal protein feeding. This is a repetition of last year's experiment to corroborate the results of last year. The animals had for their feed, groundnut cake, cotton seed meal, brewery grain, crushed gram and wheat bran for concentrates and *ragi* straw, *Jowar* silage and guinea grass for roughages, the higher protein being adjusted by an increase of the cakes with a corresponding reduction of the other concentrates. The following tables I and II show the daily average food consumption and the milk yield per head for each group. Figures are given for four weekly periods of lactation.

TABLE I.—Food consumption, milk yield and live weight of cows in high and normal protein

Periods in weeks	Dry Matter Average			Daily milk yield (lbs.)	Fat per cent			Live weight	Dry Matter Average			Daily milk yield (lbs.)	Fat per cent.			Live weight
	Bough. (Kg.)	Concen. (Kg.)	Total (Kg.)		Morn-ing	Even-ing	Aver-age		Bough. (Kg.)	Concen. (Kg.)	Total (Kg.)		Morn-ing	Even-ing	Aver-age	
In Normal				In High				Protein.								
1-4	5.657	6.079	11.736	28.6	3.6	4.3	822	6.145	6.015	12.160	27.6	3.6	4.5	4.1	840	
4-8	5.701	5.653	11.354	28.6	3.7	4.4	831	6.186	5.889	12.075	26.5	3.8	4.5	4.2	861	
8-12	5.760	5.437	11.197	24.2	3.7	4.5	848	6.187	5.215	11.402	22.8	4.1	4.8	4.5	863	
12-16	5.713	5.041	10.754	21.7	3.8	4.6	851	6.142	4.814	10.956	20.7	4.0	4.7	4.4	870	
16-20	5.700	4.341	10.041	18.8	3.8	4.7	848	6.105	4.367	10.472	18.5	4.1	4.7	4.4	872	
20-24	5.676	3.829	9.505	15.9	3.8	4.5	850	6.221	3.877	10.093	16.2	4.6	4.9	4.8	884	
24-28	5.577	3.360	8.937	12.8	4.0	4.6	861	6.222	3.498	9.720	13.1	4.6	5.2	4.9	898	

N.B.—Kilogramme into 2.2 will give weight in pounds.

TABLE II—*Food consumption by cows on high and normal protein ration (On thousand pound basis)*

Periods in weeks	A group. Normal protein.			B group. High protein.		
	Dry matter average		Total	Dry matter average		Total
	Rough- age (Kg).	Concen- trates (Kg).	(Kg).	Rough- age (Kg).	Concen- trates (Kg).	(Kg).
1—4 . . .	6·882	7·395	14·277	7·316	7·161	14·477
4—8 . . .	6·860	6·803	13·663	7·269	6·920	14·189
8—12 . . .	6·792	6·412	13·204	7·169	6·043	13·212
12—16 . . .	6·713	5·924	12·637	7·060	5·533	12·593
16—20 . . .	6·722	5·119	11·841	7·001	5·008	12·009
20—24 . . .	6·678	4·505	11·183	7·037	4·386	11·423
24—28 . . .	6·477	3·902	10·379	6·929	3·895	10·824
Average . . .	6·732	5·723	12·455	7·112	5·564	12·676

The points to be noted are :—

(1) From Table II it will be observed that the food consumption of the B group is slightly higher than that of the A group. The B group animals ate more roughage than the A group, which is reflected in the increased live weight, which on the thousand pound basis is as 1069 : 1047.

The feeds contained 5·723 Kg. and 6·203 Kg. starch equivalents having 1·175 Kg. and 1·118 Kg. of digestible protein for groups A and B respectively. These are the average figures for the whole period.

(2) The milk yield for both the groups is more or less identical, but group B has yielded richer milk, the average fat content being 4·5 and 4·2 for groups B and A. The higher fat content for group B, may be due to the higher quantity of fat ingested through the feed and not the higher protein because of the proportionately larger quantity of cake fed.

2. EXPERIMENTS WITH PHOSPHATE SUPPLEMENT

An experiment for finding out the highest phosphoric acid level that a grown up animal is capable of retaining was in progress during the year.

Plan of experiment.—Three animals were selected and they had (1) *Ragi* straw, (2) Green guinea grass and (3) Groundnut cake for their feed. Calcium phosphate, Sodium phosphate and Ammonium phosphate were given as supplements, each being taken up one after the other in the order mentioned. Phosphate supplement was given in two levels, the first having 30 gms. per day followed immediately by 60 gms. during the second stage. The period

of feeding for each of these levels was in no case less than four weeks. After the 60 gms. supplement feeding there would be a period of no phosphate for 5 to 6 weeks, before another phosphate supplement is started. Faeces and urine were collected and analysed practically throughout the whole period. Mineral balance data were obtained for the entire period. In these experiments at every stage, acid base balance of the urine was determined as also the lime and phosphoric acid of the blood.

Before the phosphate supplement the animals were showing a negative lime balance, while phosphoric acid showed a small positive balance. As soon as the supplement was given both lime and phosphoric acid became positive, but could not retain that level, when the supplement was withdrawn. This remark applies only to the figures, when Calcium phosphate supplement was given. The other analyses are not completed and so are not capable of further elucidation.

From the ordinary analyses during the above period, the digestion figures do not call for any special remarks, as there is practically no difference in the figures with and without supplement.

These experiments will be reported in detail and form the subject matter of a publication as soon as the analyses are all completed.

3. FEEDING EXPERIMENT WITH SULPHATE SUPPLEMENT

Two animals were selected and fed with Bolarum hay, green guinea grass and groundnut cake with 10 gms. of Calcium phosphate during the whole period of the experiment, the phosphate being added because the roughage is known to be poor in phosphoric acid. Preliminary digestion experiments were conducted and the mineral balance determined. Blood samples were also taken at different periods and Lime, Phosphoric acid, Sulphate and protein determined. Calcium sulphate was given as the supplement, 18 gms. being given per day. Determinations on the above lines were also conducted during this period. Since all the figures have not been collected, no general discussion is possible at the present stage. However, one tentative observation can be made, *viz.*, that the blood Ca has definitely increased and the inorganic P slightly decreased when the supplement was given.

4. PHOSPHATE FEEDING EXPERIMENT WITH GROWING ANIMALS

Plan of experiment—Eight bull calves were selected and divided into two groups, one group getting Calcium phosphate as a supplement in addition to other rations. The ration consisted of Bolarum hay, green guinea grass, wheat bran and groundnut cake. The average daily consumption and the live weight are set out below.

TABLE III—(Group) Average daily consumption of roughages and concentrates by calves

No. of Weeks.	No Mineral group, actuals in Kgs.			Mineral group, actuals in Kgs.			No Mineral group, on 1,000 lbs. basis.			Mineral group on 1,000 lbs. basis.			Live weight.
	Rough.	Concen.	Total.	Rough.	Concen.	Total.	Rough.	Concen.	Total.	Rough.	Concen.	Total.	
1 . .	2.99	1.07	4.06	2.77	1.06	3.83	9.08	3.35	12.43	8.86	3.39	12.25	1,000
2 . .	3.27	1.07	4.34	3.06	1.06	4.12	10.11	3.31	13.42	9.66	3.35	13.01	1,013
3 . .	3.26	1.06	4.32	3.12	1.05	4.17	9.72	3.16	12.88	9.58	3.15	12.73	1,042
4 . .	3.29	1.09	4.38	3.13	1.08	4.21	9.71	3.22	12.93	9.50	3.28	12.78	1,053
5 . .	3.42	1.10	4.52	3.36	1.08	4.44	9.97	3.21	13.18	10.15	3.26	13.41	1,058
6 . .	3.44	1.12	4.56	3.40	1.09	4.49	12.37	3.20	15.57	10.07	3.23	13.30	1,080
7 . .	3.54	1.13	4.67	3.44	1.12	4.56	12.47	3.16	15.63	10.03	3.27	13.30	1,097
8 . .	3.54	1.13	4.67	3.30	1.11	4.41	9.81	3.13	12.94	9.55	3.21	12.76	1,106
9 . .	3.27	1.12	4.39	3.27	1.12	4.39	8.93	3.06	11.99	9.30	3.19	12.49	1,129
10 . .	3.49	1.13	4.62	3.49	1.13	4.62	9.34	3.04	12.38	9.76	3.16	12.92	1,143

From the figures it will be noticed that the total consumption of the feed is slightly better with the 'No Mineral Group', and the live weight is also better. The experiment is continuing and detailed observations will be made as soon as it is finished.

5. PHYSIOLOGICAL STUDY OF BLOOD

In the year under report, a small beginning has been made on the study of (1) Helmenthosis as affected by nutritional changes and (2) Physiological changes in blood under different feeds. Much progress could not be made for want of proper facilities and expert advice. From the little that has been done, it is observed that under similar conditions of feeding, some animals were poor in condition and were suspected to be cases due to intestinal parasites. On the regular examination of the fæces of these animals, 3 sheep and one bullock voided ova in the fæces.

Blood counts for all the experimental animals were systematically done and in some cases differential counts were also attempted. One important observation was that, Indian cattle gave always a higher count than that recorded for European or American cattle. The recorded figure for foreign animals is only 6 million per c.c. which for Indian animals examined, gave as much as 9 millions per c.c. In the case of cross bred animals of the farm the count agrees with the figure for foreign animals.

When the animals were receiving a phosphate supplement, the counts increased and as soon as the supplement was withdrawn it decreased. Of the two animals reported, Ismail and Basappa, the former did not show as large an increase as its fellow, Basappa. The fæces of this animal, when examined, contained ova. The animals, when getting Ammonium phosphate as supplement showed the general increase in count, but the cells were irregular in shape. The following table shows these in detail :—

Red Blood Cell Count variations in Bullocks with Phosphate

Basappa Counts in millions	Ismail Counts in millions	Remarks
6,640	5,500	Normal with no Phosphate.
8,028	5,576	With 30 gms. of Sod. phos.
9,168	6,520	With 60 gms. Sod. phos.
8,593	6,270	With no Phosphate.
..	6,096	With no Phosphate.
9,320	7,440	With 30 gms. Amm. Phos.
9,456	6,512	With 60 gms. Amm. Phos.
8,416	7,720	With no Phosphate.
8,336	..	With no Phosphate.

Note.—Blood cells were counted over Burkner Hawksley chamber and ordinary Haemocytometer was used. Each figure represents the average of two or more counts from 100 small squares. [The animals had Ragi straw, Groundnut cake and green guinea grass for their feed.]

The work is proceeding and it would take much longer study to draw any definite and general conclusions.

6. DIGESTION OF FATS

Further work in connection with the common alkali hydrolysis method due to Liebermann has revealed the fact that in the presence of carbohydrates this method is not a reliable one, as there is a formation of fatty acids from this constituent due to the action of the alkali.

Experiments on ether extraction for the determination of fat have yielded the following facts. The available methods for the determination of fats in fodder and faeces by extraction do not yield quantitative results. Appreciable quantities of substances are left over which should form part of a study of fat metabolism. Repeated extractions up to about 400 hours with ethyl ether have shown that it is almost impossible to completely recover such fractions. The extract with petroleum ether is as much a mixture of non-fats as that obtained with ethyl ether. The resistant fractions have also been found to contain fatty acids in significant proportions.

A useful study of the nature and extent of the digestion of fats and fatty bodies involves this essential work of evolving a really quantitative method for their determination, especially with the chances that what is resistant to ether need not be so to the chemical and enzymic action of the digestive juices in the system. A detailed study is therefore in progress of the resistant fractions with a view to getting at a method for the quantitative determination of total lipoids in fodder, faeces, etc. The above observations are set out in detail in a paper which is submitted for publication.

All the same it was thought desirable to follow the changes in the nature of specific lipid constituents such as the sterols, phospholipins, etc., during the process of digestion. An attempt has latterly been made to isolate the sterols in fodder and faeces and make a qualitative study of these. Work has not proceeded far enough to draw any conclusions.

7. EXPERIMENTS WITH SHEEP

The Sulphur metabolism studies were continued during the year. A new method for the determination of total sulphur in animal and vegetable material was worked out. Briefly the process consists of Nitric acid oxidation of the material followed by alkali fusion. Unless absolutely complete oxidation of organic matter takes place Nitric acid alone failed to convert all the Sulphur to sulphate. By fusing the product of Nitric acid oxidation it was found possible to reduce the time of oxidation enormously. Fusion also enables much larger quantities of material to be tackled, besides completing the oxidation of the Sulphur thus increasing the accuracy of the

determination especially of Sulphur poor material like straw. The following table gives yields of Barium sulphate from identical quantities of the same material with and without fusion. The results indicate the importance of fusion.

Effect of fusion on the yield of Sulphur in different substances

Substances	Yield of Barium Sulphate in mgms.	
	Without Fusion	After Fusion
Hay	61.5	65.0
Guinea grass	75.5	87.5
Groundnut cake	101.5	104.0
Urine	115.5	119.0
Fæces	86.5	92.0
Wool	93.0	95.5

A long period feeding test was carried out with sheep to study their wool production and Sulphur balance and several digestion experiments were also done. During the course of nearly 18 months the animals consumed daily on an average per 100 lbs. live weight, 1,206 gms. of dry matter containing 78.4 gms. of crude protein and yielding 0.85 lbs. of starch equivalent. They digested on an average 52.7 per cent. of the organic matter and 57.2 per cent. of the crude protein of their ration.

It was found that the live weights fluctuated somewhat roughly in accordance with food consumption and that the individual animals differed considerably in their efficiency for utilisation of food. Digestion experiments indicated that the food varied somewhat in quality and that consumption increased when the quality improved. The extent of such increased consumption was considerable.

Although the wool yields of these sheep are insignificant the important observation was made that yields fluctuated according to the nutritional state of the animals. The following table makes this point clear.

TABLE 4
Wool production in relation to live weight excess over initial live weight

Sheep Nos.	1	2	3	4	5	6	7	8
	*L. W. Wool Ex. gms.	L. W. Wool Ex. gms.	L. W. Wool Ex. gms.	L. W. Wool Ex. gms.	L. W. Wool Ex. gms.	L. W. Wool Ex. gms.	L. W. Wool Ex. gms.	L. W. Wool Ex. gms.
First period	6 338	6 289	-2 268	.. 375	7 249	8 280	7 404	.. 345
Second period	3 280	3 235	-2 250	-3 375	6 235	8 290	11 445	-1 345
Third period	7 350	6 320	0 314	-2 460	7 320	10 360	12 520	0 355

* Live weight excess pounds.

It was also noticed that shearing of sheep during cold weather caused a serious loss of weight and consequently the animals suffered in their productivity also. The following table illustrates this point. The first shearing was done in the cold weather (January) and the second in hot weather (July).

Shearing Effect

Sheep Nos.	1	2	3	5	6	7
<i>First period</i>						
Initial weight . . . lbs.	67	52	47	63	55	47
Final weight . . . "	73	58	45	70	63	54
Gain . . . "	6	6	—2	7	8	7
Shearing effect . . . "	—5	—5	—3	—4	—3	—3
<i>Second period</i>						
Initial weight . . . lbs.	68	54	42	66	60	51
Final weight . . . "	70	55	45	69	63	58
Gain . . . "	2	1	3	3	3	7
Shearing effect . . . "	0	—1	—1	—2	—2	—2

The same set of sheep were employed simultaneously for the study of the effect of a supplement of Sodium sulphate. It was found that in the process of alimentation there is always a loss of total Sulphur and sulphate. When the sulphate content of the ration is low the loss of total Sulphur is very small. It was possible in such cases to account for almost all the ingested Sulphur. On the other hand when the amount of sulphate in the ration is considerable a large real loss of Sulphur occurs, indicating that volatile Sulphur compounds (H_2S , etc.,) are formed. The following tables indicate this.

Loss of Total Sulphur

—	Intake	Balance (loss)	Accounted for in wool and live weight increase	Unaccounted (loss)
With supplement . .	1.386	0.179	0.070	0.109
Without supplement .	0.809	0.085	0.078	0.007

Gain of Organic Sulphur

Sulphate Balance. Gain of Organic Sulphur contained in :—

	Sulphate Balance		Gain of Organic Sulphur contained in :—			Unaccounted (Loss)
	Intake	Balance (loss)	Urine and Faeces	Wool and Live weight increase	Total	
With supplement	0.916	0.221	0.042	0.070	0.112	0.109
Without supplement	0.337	0.064	0.023	0.078	0.055	0.009

In contrast to the losses of total Sulphur and sulphate Sulphur it was found that a gain of organic Sulphur occurs. This organic Sulphur is formed from sulphate and the amount produced increased with the amount of sulphate ingested. That this increment of organic Sulphur plays a part in metabolism of the animal is indicated by the fact that the organic Sulphur content of the urine is increased by ingestion of inorganic sulphate. These results have been submitted for publication in a series of papers.

8. SULPHUR IN GRASSES

The Sulphur distribution in grasses has been under enquiry during the year. It has been noticed that the water soluble non-protein organic Sulphur of some grasses fail to give the nitroprusside test besides incurring no loss whatsoever even after repeated treatments with Hydrochloric acid. There is, therefore, reason to believe that the Sulphur in these compounds is at least partially oxidised.

Regarding the sulphate content of grasses the important observation has been made that the tribe of the grass has decided characteristics in having high or low sulphate content. It has been noticed that the Chloridæ contain the maximum amount of sulphate, while the Andropogonæ, the Panicæ, etc., contain much less. The following figures collected from the analysis of grasses growing together in plots only a few square feet in area will make the point clear.

Sulphate content of Grasses

(Sulphate expressed as gms. Sulphur per cent)

Name of Grasses	Plot 1	Plot 2	Plot 3
<i>Andropogon annulatus</i> . . .	..	..	0.055
<i>Andropogon contortus</i> . . .	0.069	..	0.044
<i>Andropogon pertusus</i> . . .	0.045	..	..
<i>Chloris barbata</i> . . .	0.290	0.218	0.180
<i>Cymbopogon</i> . . .	..	..	0.058
<i>Digitaria sanguinalis</i> . . .	0.052	..	..
<i>Eleusine</i> . . .	0.185	..	..
<i>Eragrostis</i> . . .	0.047	..	0.052
<i>Panicum javanicum</i> . . .	..	0.069	0.061
<i>Panicum maximum</i> . . .	0.038	0.068	..

9. MINERAL METABOLISM EXPERIMENTS

Influence of progressive ripening of some fodders on the mineral nutrition of cattle was studied and reported. The fodders examined were :—

1. Rhodes grass 2 cuts
2. Aurangabad hay 3 cuts
3. Spear grass hay 2 cuts
4. Jowar hay 3 cuts

The mineral content was found to vary from fodder to fodder and with the state of maturity. It was found that the state of maturity greatly affected the mineral assimilation. From the data obtained it was found that to produce a positive balance with Lime and Phosphoric acid under minimum maintenance conditions the amount present in the feed should not be less than 15 gms. CaO, 10 gms. P_2O_5 for an animal of 750 lbs. live weight, when other conditions are favourable. It appears that with less Lime and Phosphoric acid than these amounts, no positive balance is possible under any circumstances. Another interesting point is that while a positive Lime balance can be obtained, when the Lime is above the minimum, but the Phosphoric acid below, the converse *viz.*, a positive Phosphoric acid balance, when Lime is below the minimum seems unattainable.

10. ACID BASE EQUILIBRIUM

The study of the influence of progressive ripening of fodders on the acid base balance of urine was continued during the year. Four typical fodders at different stages of maturity were fed to

cattle and the resulting urines studied. Some important results were obtained. The data are presented in the following table :—

Urinary excretion of acids and bases in c. c. N per 1000 gms. Fodder.

---	Total fixed bases	Total acids	Excess of base	CO ₂	Ammonia	pH of urine	Volume of urine in litres per day
1. Rhodes grass hay (Bangalore)—							
1st cut .	818.7	507.2	311.5	488.8	7.6	7.98	10.105
2nd cut .	518.3	506.5	11.8	40.9	5.8	7.40	5.891
2. Aurangabad hay—							
1st cut .	264.5	249.1	15.4	36.3	6.7	6.62	3.074
2nd cut .	202.1	190.0	12.1	18.5	8.4	6.25	1.912
3rd cut .	138.5	158.0	-19.5	1.5	10.8	5.72	1.861
3. Spear grass hay (Bangalore)—							
1st cut .	296.7	296.6	0.1	40.5	7.9	7.22	5.820
2nd cut .	187.5	189.2	-51.7	1.8	68.7	5.85	2.074
4. Jowar hay—							
1st cut .	655.4	414.5	240.9	274.6	5.4	7.90	5.964
2nd cut .	411.4	328.8	88.1	115.8	5.5	7.60	4.131
3rd cut .	330.1	290.0	40.1	41.9	8.3	7.40	3.543

It may be noticed that the early cut fodders are marked by the production of large volumes of urine which may be definitely attributed to the high amount of alkalis present therein. With later cuts the volumes decrease. There is also the decrease in the excretion of fixed bases in the urine as the stage of maturity of the crop advances and consequently the pH of the urine tends to become lower and for the same reason the carbon dioxide content of the urine also diminishes. Some of the later cut fodders are distinctly acid. In the case of Aurangabad hay and Spear grass hay the bases excreted are low even in the early cut samples and later cuts show serious deficiency of bases. Spear grass hay may be said to produce nutritional acidosis, marked by a large increase of urinary Ammonia.

Another point which may be noticed is that although fodders 1 and 3 were grown on similar soil, yet the one has produced an alkaline urine and the other an acid urine. The species of grass and the stage of maturity both profoundly influence the mineral supply to and the acid base balance in the animal.

Another observation that was made is the increased deflection of lime and magnesia into the acidic urine, the excretion being not proportional to the intake but depending almost entirely on the pH of the urine. This suggests, therefore, that the animal experiences difficulty in retaining minerals when the urine becomes acid. Mineral balance experiments done go to confirm this view.

All these are more fully dealt with in a paper which has been submitted for publication in the Indian Journal of Veterinary Science and Animal Husbandry.

An important study of the effect of feeding different phosphates to cattle fed with a basal ration on the gradual change in the nature of the urine and in the acid base balance of urine has been undertaken and would be fully dealt with later on.

11. CALCIUM AND PHOSPHOROUS CONTENT OF BLOOD SERUM

The Ca and P content of the blood serum of the animals with three of the four fodders at different stages of maturity is given in Table V below.

TABLE V

Effect of Ca/P ratio of Fodder on Serum Ca and inorganic P.

—	Ca intake per day gm.	P intake per day gm.	Ca/P ratio, per cent.	P in serum Mgm. per cent.	Ca in serum Mgm. per cent.	Acid base balance in urine o. o. N. alkali per day.
Aurangabad hay—						
1st cut . . .	20.19	5.85	3.78	5.08	10.84	67.2
2nd cut . . .	17.56	4.00	4.38	5.11	11.76	58.2
3rd cut . . .	19.92	3.00	6.63	4.94	13.18	-94.4
Spear grass hay—						
1st cut . . .	18.42	7.93	2.32	5.99	11.88	-0.9
2nd cut . . .	19.29	4.81	4.01	5.48	13.17	-248.0
Jowar hay—						
1st cut . . .	13.05	10.53	1.24	6.08	11.15	1119.8
2nd cut . . .	10.20	10.14	1.01	5.39	10.85	368.8
3rd cut . . .	7.65	12.78	0.60	6.08	12.60	186.8

It will be seen that the blood serum P value does not vary according to intake alone, but is also dependent on the nature of the fodder. For example in the Spear grass hay test with an intake of 4.81 gr. P, the serum P level was found to be 5.48 m. g. and in the former test, with much higher intake of 10.14 gr. P, the serum P level was only 5.39 m. g.

Blood calcium varies with different fodders. It is not related to the Calcium content of the food, and there is no direct relationship between the Ca/P ratio and the serum Calcium, but the blood Calcium level is influenced by the nature of the food and the stage of maturity of the fodder.

Serum Calcium is frequently parallel to the acid base balance and the urinary excretion of Calcium; but there are important exceptions to these rules.

12. MINERALS IN PASTURE GRASSES

Mineral composition of three pure species, *Andropogon contortus*, *Cynodon dactylon* and *Pennisetum cenchroides*, grown

at Pusa, Sabour and Bangalore for two consecutive seasons was studied and submitted for publication. The following factors were noted :

Distinct differences in mineral content of the grasses are noticed due to the nature of the soil. For example, the grasses grown at Pusa invariably contain more Lime and less Phosphoric acid than the average, the soil itself containing as much as 18 per cent. CaO.

It was found that each species of the grass showed a tendency towards a mineral make up peculiar to itself, *Cynodon dactylon* invariably showed a considerable excess of lime over phosphoric acid, while in *Pennisetum cenchroides*, the tendency was for Phosphoric acid to exceed Lime. The latter is an unusual phenomenon and is observed only in two other species, viz., Guinea Grass and Jowar, grown at Bangalore.

The maturing of grass was found to exert a considerable influence on the per cent. of Nitrogen and Potash in the grass, a smaller influence on the per cent. of P_2O_5 and only a minor effect on the per cent. of Lime and Magnesia.

III. PUBLICATIONS

The following papers were sent for publication during the year under report :--

1. The influence of Progressive Ripening of Fodders on the Mineral Nutrition of Cattle, Part I. Mineral Composition and the Mineral Balance as influenced by progressive ripening of Fodders, by A. Viswanatha Iyer, Assistant Physiological Chemist.
2. The Influence of Progressive Ripening of Fodders on the Mineral Nutrition of Cattle, Part II, Urine characteristic as influenced by progressive ripening of fodders, by N. Krishna Ayyar, Assistant to the Physiological Chemist.
3. The Influence of Progressive Ripening of Fodders on the Mineral Nutrition of Cattle, Part III, The Blood characteristics as influenced by progressive ripening of fodders, by N. C. Das Gupta, Assistant to the Physiological Chemist.
4. Minerals in Grasses in India, by A. Viswanatha Iyer, Asst. Phys. Chemist.
5. The Determination of Sulphur in Balances with Cattle and Sheep, by N. S. Krishnan, Animal Nutrition Section, Bangalore & T. S. Fieldman, Animal Nutrition Section, Bangalore.
6. A New Bleeding Rack, by N. S. Sankaranarayanan, Fieldman, Animal Nutrition Section, Bangalore.

7. On the Unsuitability of the Existing Methods for the Determination of Fats in Biological Materials, by P. A. Seshan, Animal Nutrition Section, Bangalore.
8. A Feeding Experiment with Sheep, by F. J. Warth & T. S. Krishnan, Animal Nutrition Section, Bangalore.
9. Sulphur and Sulphate Balance Experiment with Sheep, by F. J. Warth & T. S. Krishnan, Animal Nutrition Section, Bangalore.
10. Minerals in Pasture Grasses in India, by A. Viswanatha Iyer, Assistant Physiological Chemist. (Prepared for the use of The Imperial Bureau of Plant Genetics, Great Britain).

IV. PROGRAMME OF WORK FOR 1935-36

MAJOR SUBJECTS

1. Experiments in the Nutrition of growing Animals
2. Experiments on milk production, including mineral assimilation
3. A study of Indian coarse fodders
4. Indian pasture grasses ; a survey of their mineral composition
5. Blood analysis
6. Sheep-feeding experiments
7. Physiological Studies

MINOR SUBJECTS

1. A study of the chemical methods employed in the above enquiries
2. Preliminary experiments for the initiation of work on other aspects of Nutrition

